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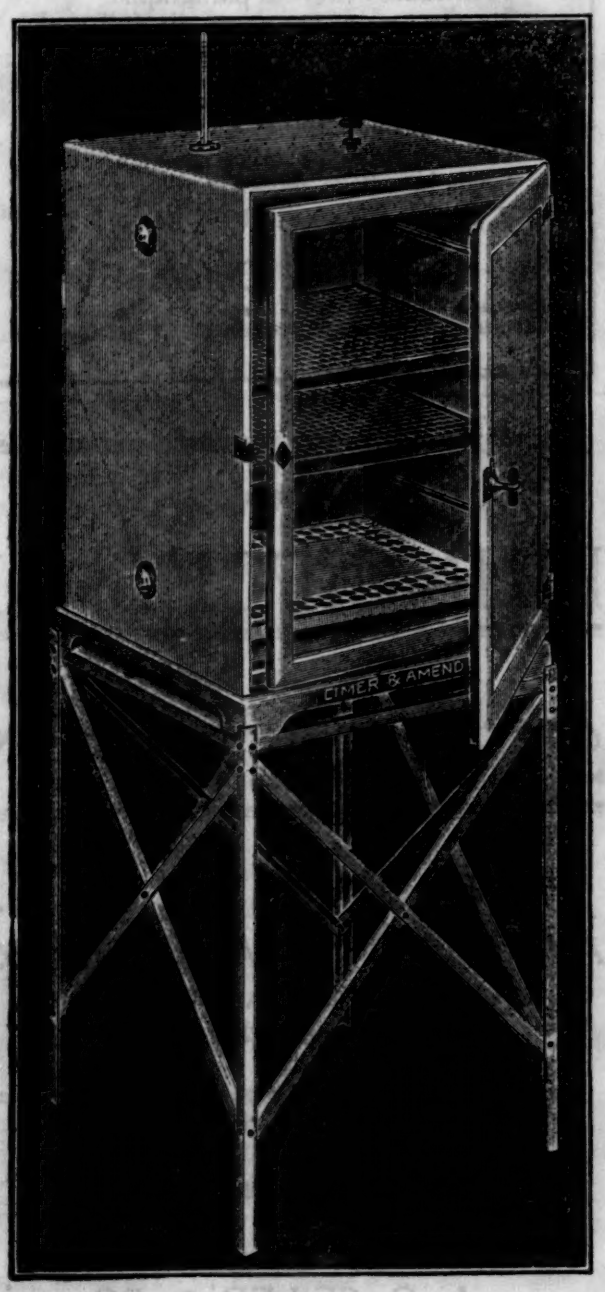

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THE LIFE AND WORK OF CARL LUDWIG[1]

WE are gathered together as teachers and investigators to commemorate the life of a teacher of teachers and an inspirer of investigators. We represent many phases of academic activities, most of which are far removed from the special branch of science to which Ludwig devoted his life. Therefore, only a greatly condensed account of his physiological discoveries will be given, and most of this paper will be devoted to his life, and an attempt to bring out from the testimony of his old pupils and friends, the traits of character which gave him his remarkable power as a scientist, and enabled him to win the reverence and, I may say, the love, of all those who had the good fortune to work with him as students and colleagues.

Carl Frederick Wilhelm Ludwig was born in Witzenhausen, a little town on the banks of the Weser, not far from Cassel, in the electorate of Hesse, December 29, 1816. His father, an officer in the Napoleonic wars, had been compelled by wounds to give up a military career, and being in favor with the elector, was appointed Rentmeister in Hanau. Ludwig came from a race of fighters, and a deep scar on his upper lip gave evidence of his participation in student duels. He was proud of his descent, and I recall an amusing reference which he made to the fact that the Hessians had played a part in the early history of our land.

He was the second of six children, who

[1] Read before the Research Club of the University of Michigan, at the "Memorial Meeting," April 19, 1916, by Warren P. Lombard.

were carefully trained at home by a wise and affectionate mother. At the close of his school days at the Gymnasium in Hanau, he was sent to the University of Marburg, where his student days were stormy. Indeed, as a result of conflicts with the disciplinary authorities, some say because of political activities, he was forced to leave for a time. He studied at Erlangen, and spent one year at the surgical school at Bamburg, finally returning to Marburg, where he took his doctor's degree in 1839. Continuing his studies, he was appointed, in 1841, second prosector of anatomy under Ludwig Fick. The following year he was formally admitted to the faculty of the university.

Ludwig has often been incorrectly numbered one of the pupils of Johannes Müller, but Tigerstedt states that he was a finished physiologist when he first visited Berlin, and that the one of the older scientists who exerted the greatest influence on Ludwig was Ernst Heinrich Weber. Even in his old age Ludwig spoke with the greatest admiration of his predecessor in Leipzig, and could not say enough of the tremendous importance of the part played by Weber in the development of science.

In 1846 he was appointed ausserordentlich professor of comparative anatomy at Marburg, and in 1849 professor of anatomy and physiology at Zurich. It was in this year that he married Christine Endemann, who with loving care watched over him, guarding with affectionate solicitude his somewhat frail health, making possible his life-long devotion to science.

In 1855 Ludwig was called to Vienna as professor of physiology and zoology at the academy for army physicians—the Josephinum—and in 1865 he succeeded Ernst Heinrich Weber in Leipzig, receiving the title of professor of physiology and director of the physiological institute, which was about to be constructed.

A list of the honors which have been conferred upon a man is of interest as an indication of the way he was regarded by his contemporaries. Ludwig's titles in the register of the University of Leipzig read as follows: Ehrendoctor der Philosophie der Universität Leipzig, Königlich sächsischer Geheimer Rath, Comthur I Klasse des Königl. sächsischen Albrechtsordens mit dem Stern, Comthur 2. Klasse des Königl. sachsischen Verdienstordens, Ritter des Königl. preussischen Ordens pour le mérite unde des Königl. bayerischen Maximilianordens für Wissenschaft und Kunst, Inhaber der Copley Medal of the London Royal Society, Commandeur I Klasse des Königl. schwedischen Nordsternordens, und Ehrenbürger der Stadt Leipzig (this last honor being given on the occasion of the celebration of his fiftieth Doctor's jubilee). In addition he was a member of the Akademien der Wissenschaften in Berlin, Wien, München, Paris, Petersburg, Rome, Turin, Stockholm, Upsala, et cetera.

The period when Ludwig was entering upon his physiological work was one of unrest in medical as well as political thought. Modern biological conceptions can be said to date from that time. The greatest physiologists of the day in Germany, Johannes Müller and Liebig, while recognizing that living beings are influenced by the physical and chemical forces which govern inorganic things, assumed the existence of some mysterious force within the bodies of animals and men, which caused life processes to take a different course from those occurring in inanimate objects. Only death released the atoms from this mysterious influence and permitted them to act as they did outside of living organisms.

This vitalistic doctrine was combated and for a time at least overthrown by the scientific work of the pupils of Johannes

Müller, Helmholtz, Du Bois-Reymond and Brücke and by Ludwig.

Helmholtz, recognizing the limitations set by the existing chemical and physical knowledge, devoted himself only to those branches of science which seemed capable of exact chemical and physical explanation; Du Bois-Reymond contented himself with the study of the narrow field of electrical phenomena of living organisms, and did more than any one else to show that physiological problems are capable of being handled with the same precision as the purely physical; Ludwig, with characteristic fearlessness and enthusiasm, attacked problem after problem, striving to find out how many of the subtle processes of life were susceptible of a mechanical explanation.

Ludwig's "Lehrbuch der Physiologie des Menschen," the first edition of which came out from 1852–1856, and the second, from 1858–1861, was dedicated to his friends, Brücke, in Vienna, Du Bois-Reymond, in Berlin, and Helmholtz, in Bonn. The writer's point of view was diametrically opposed to that of his predecessors. Throughout the book the explanation for vital processes is sought in pure mechanics, in the widest sense. He wrote in the introduction:

> The problem of scientific physiology is to determine the functions of the animal body and deduce them as a necessity from its elementary conditions.
>
> Whenever the body of an animal is subdivided to its ultimate parts, one always finally arrives at a limited number of chemical atoms, and upon phenomena which are explainable on the assumption of a light ether and electricity. One draws the conclusion in harmony with this observation, that all forms of activity arising in the animal body must be a result of the simple attractions and repulsions which would be observed on the coming together of those elementary objects. This conclusion would be unassailable, if it were possible to show with mathematical accuracy, that the elementary conditions were so arranged in the animal body with respect to direction, time and quantity, that all of the phenomena of living and dead organisms must necessarily flow from their interaction.
>
> This conception, as is well known, is not the traditional; it is the one among the newer, which, as especially opposed to the vitalistic, has been named the physical. The view, aside from all details, finds its justification in the irrefutable demand of logic, that a cause shall underlie every result, and further in the soundest rule of every experimental science, that one draws only on absolutely necessary grounds of explanation.

Du Bois-Reymond toward the end of the year 1848 said:

> The belief in a vital force, like the other dogmas, depends less on scientific conviction than the need of a soul to certain organizations; that is why this belief, like that of the dogmas, can not be rooted out.

The slowness with which the new view was accepted is demonstrated by the fact stated by Kronecker, that Claude Bernard, only towards the end of his life, 1876, made the definite statement:

> Que les conditions de manifestations de la vie sont purement physico-chemique et ne diffèrent par sous ce rapport des conditions de tous les autres phénomènes de la nature.

In 1895 Mosso wrote from Italy:

> After a short truce during which vitalism appeared to be abandoned, we see it born again under another form. Literature and art bear witness to the reaction which produces itself, and on all sides one detects the breath of mysticism which invades the mind. The school of the neo-vitalists has already conquered the pulpit, and many fear that it will stifle the spirit of true science, as it has done in the Catholic universities.

Tigerstedt, one of Ludwig's favorite pupils, who has become one of the best known of the physiologists of our time, and who, although a Finn, was unanimously chosen as president of the International Congress of Physiologists, which was to have met in Paris this autumn, gives perhaps the best expression of the attitude of the present-day physiologists:

In the newest physiology there is noticeable an undercurrent which offers as its conception with always less reservation that not even the simplest life processes, as for example respiratory gas exchange and lymph formation, can be explained wholly on a physico-chemical basis, but that they chiefly depend on vital processes in the cells. . . . But this new vitalism distinguishes itself in a very important point from the old. It does not assume the existence of a peculiar, mystic vital force, and does not break away from the fundamental view, which the last fifty years have made the unalterable possession of physiology, with the truth that the principle of the conservation of energy applies to living as well as to dead nature. This being so, it is of relatively secondary importance whether the complicated processes, which take place in living beings, can or can not be explained by the physics and chemistry of our time. In any case they follow definite laws, and are not called out by a whimsical power, which can at the one instant be indefinitely strong and at the next nul. So if we say that this or that process is attributable to cell activity, that signifies nothing else than that our present physical and chemical knowledge is still insufficient to completely explain these processes, and that the right explanation will possibly only be found if the forces working within the cell lie more clearly in the sight of the experimenter.

And if it were true that many theories which Ludwig expressed had lost some of the likelihood which they formerly seemed to have, what has that to do with their importance for our science? In all natural science we meet the observation that theories have only a limited life, that one theory after a shorter or a longer time must give place to another, which can indicate more completely or better than its predecessor the character of the phenomena which it should explain. A theory is then good, and has an importance in the development of science, if it is of such a kind that it leads to new investigations, based on direct observation of nature, through which science wins in breadth and depth. If through it such facts shall be discovered as are not in harmony with the theory, which they have, nevertheless, to thank for their discovery, then the theory falls. But it falls with honor, for it has led to the discovery of new truths, and has constructed an important link in the development of science. Whatever the fate of Ludwig's theoretical views, we can surely say that they have greatly enriched science, and so bear the stamp that is the sign of good theories.

It is interesting to read the estimation of Ludwig's character and his methods of work by another great investigator, Wilhelm His, the great Leipzig anatomist:

Ludwig's weapons of research were an uncommon sharpness of analysis of living processes under observation, an always clear formulation of the question, and an absolute reliability of the method of attack. It was of great importance for his career that he was a schooled anatomist and controlled microscopical technique to a remarkable degree. From his anatomical knowledge came his consummate and careful technique as an experimenter on living animals, in which only Magendie and Claude Bernard are to be compared with him. Moreover, he had at his command a shrewd intuition, without which the clearest thinker is often powerless in the investigation of living processes. Nature does not always allow herself to be conquered by logic, her ways are frequently hidden, and she reveals herself only to him who has sharpened his sight for insignificant traces, by persistent, faithful observation. Ludwig had to a high degree a love for personal observation, and a successful preparation or a striking experiment was for him an esthetic pleasure. He placed direct perception, in the study of living nature, far above working with abstract conceptions.

As has been said, when Ludwig was appointed to the chair of physiology in Leipzig his first task was the planning of a physiological institute. This institute was the seat of Ludwig's labors for nearly thirty years; it saw the development of many of the greatest physiologists of the past five decades; it was the birthplace of discoveries which have been of inestimable value to medical thought; and the remarkable success of the ideals and methods which he, as director, put into practise, caused it to become the model for many others. The plan is a witness of his breadth of view, and the recognition that the problems of physiology can be solved only through a knowledge of the structure of the parts involved, and a study of both the physical and chemical changes occurring within them, and that under ideal conditions, all of these forms of work should go

on side by side. The building had the form of a capital E. The main portion was arranged and equipped for the study of physiological processes from the physical side, one wing was devoted to histological work, the other, to physiological chemistry. The lecture room, closely connected to the main part of the building, occupied the space between the wings. Above the laboratories, but completely separated from them, were the dwelling rooms of the professor and his family.

Ludwig reserved a well-lighted corner room for his private office. The door which communicated with the main laboratory was, however, very rarely closed, and his room was the passageway to the small adjoining room which contained the library, to which those working with him had access at all times. The books, largely journals, were free to the use of all, and could be even taken home, the only restriction being that the borrower should enter the book and his name.

His says that Ludwig's customary greeting, when His entered his chamber was, "Was giebtes neues?" The news for which he thirsted was not the gossip of the day, but suggestion for a new scientific problem, a new method of attack, the recital of some successful piece of research work.

When the London Royal Society presented the Copley medal to Ludwig, it was given not so much because of the important investigations which had appeared under his name, as because of the vast number of researches which he had conducted with the aid of his pupils, but in which his name failed to appear, and the still greater number, which were the result of the inspiration which those who had worked with him carried away, often to distant lands, and in their turn imparted to others.

Ludwig was truly remarkable for his ability to utilize the work of the young and inexperienced. A great school of physiology developed under him at Leipzig, with an activity with which only Liebig's chemical laboratory in Giessen could be compared. As many as nine or ten men, from almost as many different countries, might be found working in his institute at the same time, and this international circle lived, as Kronecker said, under the influence of the refined, kindly knower of men, in perfect harmony.[2]

Why was Ludwig's laboratory always full when the other German physiological laboratories had only one or two workers? The instant one entered it, he felt that it was a place where things worth doing were being done. Ludwig's enthusiasm pervaded it, and it was an intense pleasure to work in the stimulating atmosphere. I can recall Ludwig's joyous shout, as he called all who could leave their work to come and witness some physiological process revealing itself in its true light for the first time, or some unusually suggestive histological or anatomical preparation. And then came one of those delightful talks, leading us forward to the border land of science, and giving us glimpses into that fascinating, mysterious land—the unknown. I must admit that at such times, Ludwig's active mind sometimes, leaping over lines of thought which were new to us, often out-

[2] The following Americans were pupils of Ludwig: Gerau, of New York, 1845–46; Bowditch, of Boston, the first and best known of American physiologists, for many years professor at the Harvard Medical School, 1869–71; Minot, of Boston, one of the foremost of American embryologists, also many years professor at the Harvard Medical School, 1873–74; Abel, now professor of pharmacology at Johns Hopkins and formerly filling the chair in this university, who has a very high reputation, 1884; Mall, one of our graduates, now professor at Johns Hopkins, and probably the strongest anatomist in this country, 1885; Lee, professor of physiology at the medical department of Columbia, New York, who has done excellent work, 1886.

stripped his listeners. I thought that, in my own case, it was my incomplete knowledge of the language that was at fault, but I remember that von Frey, who was then docent in physiology, said that frequently he could not follow Ludwig.

Another thing that drew men from distant lands to his laboratory was the fact that it was well known that he never made use of his students for his own immediate glory, and that the researches which he inspired, and even those in which he did the most difficult part of the experimentation, were at all times treated as the personal investigations of those who worked with him, and were published under their names. As evidence of his unheard-of self-denial, Tigerstedt offers his own case. Having carried through a piece of work at Ludwig's suggestion, he sent him the manuscript from Stockholm for his criticism. The only correction which he made was to strike out the words, "Stetiger Beihülfe vom Herrn professor Ludwig."

It has often been said that Ludwig was absolutely unselfish in the lavish way in which he gave his ideas to others. He had so many ideas that he could well afford to be generous; he loved his science and rejoiced in the scientific achievements of his pupils; he was, moreover, worldly wise, in the best sense.

> Oh, if we draw a circle premature,
> Heedless of far gain,
> Greedy for quick returns of profit, sure
> Bad is our bargain.

The wonderful richness of the uninterrupted series of papers, published from his laboratory during the 56 years of his activity, was only made possible by his skilful division of labor, and his capacity to estimate the abilities and tastes of those who worked with him. Each man had his own clearly defined problem, and the problems were as distinct as the men. It was remarkable how many different forms of research he could supervise at the same time and keep them all clearly in mind. When I was working with him there were Wooldrich, who was studying the effect of stimulating special parts of the heart of the dog; Stolnikow, the rate of flow of the blood; Tigerstedt, the latent period of muscle; von Frey and Grubler, metabolism of isolated muscle when at rest and in action; Bohr, the way gases enter and leave the blood in the lung; myself, the method of spread of reflex processes in the spinal cord; and Miss Smith, who was working on a histological subject with Gaule, and others, working under Drechsel, on problems in physiological chemistry, among whom was Abel, now professor of pharmacology at Johns Hopkins.

You might be interested to know his daily routine. Every morning he visited the tables of the different men and discussed with them the next step to be taken, often appointing the hour when he would take part in the research with them (and the appointment was always punctually kept); or he would take them into his private room and critically discuss the methods employed, making suggestions as to the direction in which new and more effective methods could be sought, carefully go over the curves and other data already obtained and the inferences to be drawn from them. This was not done offhand, for each night when he left the laboratory he carried to his rooms above, records and protocols of investigations in progress, for careful study.

An hour or more was devoted to the preparation of his lectures, which were given at four o'clock and were richly illustrated with experiments. In the preparation of the experiments he was assisted by the mechanic of the laboratory, Salfamoser, who had come with him from Vienna to Leipzig. No account of Ludwig and

his laboratory would be complete without mention of Salfamoser. He had worked with Ludwig so long that he was thoroughly familiar with the routine of the laboratory and even the most complicated experimental methods. He was the first instructor of many a pupil in the technique of the operations which he had to perform, as well as the use of the apparatus. When Ludwig himself took part in operative experiments, Salfamoser often acted as his assistant, and, not infrequently, to the disgust of Ludwig, as his adviser. I can recall seeing Ludwig draw himself up and say to Salfamoser, "Who is the professor here, you or I?" "Oh, you are Herr Professor; nevertheless, I am right." Salfamoser was devoted to Ludwig, and Ludwig, fully recognizing his faithfulness and his ability, depended on him as one depends on his hands.

Ludwig's lectures were addressed to the most advanced of his students, and were attended by all of those working in the laboratory. The beginner had a hard time, and almost all of the ordinary students attended the course twice before presenting themselves for examination. Ludwig entered into his lectures with the same earnestness and vigor that characterized all of his activities. I attended, if I recall rightly, his forty-seventh course, and I never saw him enter the lecture-room that he did not change color. He did not know what it was to be blasé.

After his lecture he frequently went for a walk unless he had to attend the examination of some student, a task which he loathed. There was no work done in the laboratory Saturday afternoon, when it was left to the mercy of the scrubwomen; and no work was done on Sunday.

His intense interest in the problems that he was studying was infectious; his enthusiasm imparted itself to his pupils, and aroused all of their ingenuity and their best powers of observation and thought. Ludwig's untiring energy in the hunt, inspired the pupil with an unknown constancy of effort, the problem possessed him day and night, and when he began to dream of it the light began to dawn.

My own case must have found its counterpart in that of many others. I entered his laboratory knowing physiology only as I had learned it in the lecture-room. He assigned my problem, started me upon the method which at the outset seemed the most promising, and followed each advance with close attention. When I reported that I had found something new, he would ask me to show my records and prove to him that I had really found what I supposed. Even when the facts reported had long been known, no cold water was thrown on my enthusiasm, and I was allowed to have the supreme pleasure of having made, as I truly had, a discovery. And so he led me on, often helping me with the experiments themselves, and when, at the end of a year and a half, I had brought my results together and written the first draft of my paper in English, he put it into German, practically rewriting it. I shall never forget my feeling of embarrassment, as I said to him that I felt that I had no right to let the paper appear under my name, for I had been only his hands; that it was really his work and not mine. "It is all right," he said, "it has been your work." Then he added, "But if you never do anything else, it will be thought that you did not do this."

Ludwig did not know how to fail: once started on a trail he would follow it for years. He once said to me, "Never let nature get the better of you; if you do, she will take advantage of you next time."

He would never permit slovenly work. I remember one day he asked me to make

an iron hook which we needed. I bent one which I thought would do, but without criticizing it directly, he proceeded, while discussing the work, to painstakingly rebend it, until it exactly fitted our need. I carried that hook in my pocket for years, and although I finally lost it, the lesson has clung.

He taught his students independence. On one occasion when I offered to help him tie a ligature in a difficult place, he said with a merry smile, "No, no; if I let you help me now, you will want me to come and help you the next time you have a knot to tie."

Kronecker said of him:

> He understood how to instil his ideas so that those working under him often thought them their own. But he wished to bring out his own characteristic methods of expression when it came to the publication of the work, and every expert was able to recognize in the papers coming from the Leipzig institute the hidden thoughtful exposition of the master.

Von Frey admirably described his characteristics when he wrote,

> The steadfastness with which Ludwig clung to the complete control of the direction of the work, might suggest a form of military discipline in the laboratory. This certainly did not apply to the personal relations which existed. Nevertheless, such a comparison is not without value for an understanding of the exceptional results of his teaching. Among other qualities Ludwig possessed those which could be described as marked military virtues: boldness of design, tenacious perseverance in execution, presence of mind and high personal courage, an unusual talent for organization bound up with a knowledge of men, which knew how to put every force in its right place, strict discipline, frankness and heartiness in personal relations, indefatigableness in work, together with exemplary orderliness and punctuality.

With the love which our master inspired, there developed in the laboratory an esprit de corps, so that to have worked with him was a password that gave free entrance to the laboratory and the friendship of every other who had been his pupil.

Ludwig's old students, in token of their esteem, on the occasion of his twenty-fifth anniversary as ordentlicher professor, presented him with a Festschrift. In this was a list of his pupils up to that time, which numbered 142. In the twenty years that followed, a hundred others worked with him.

Many of Ludwig's researches were purely anatomical, or the physiological problems were handled chiefly on an anatomical basis. One thinks of the structure of the heart and its relation to its change of form, and of his attempts to bring the structure and course of the blood vessels in various organs into the explanation of their function. The excellent methods of injection of blood vessels developed in his laboratory, made it possible for him to study the circulation in many organs as it had never been done before, *e. g.*, in the eye, ear drum, liver, lymph glands, corpora cavernosa, intestines, muscle, ear-labyrinth, larynx, skin. Especially worthy of mention is the natural injection of the lymph spaces, by means of which Schweiger-Seidel and Ludwig studied the lymphatics of the pleura, the central tendon of the diaphragm, the retina and the liver.

As far as is known, his first physiological research was his habilitationsschrift, "Beiträge zur Mechanismus der Harnsecretion," published in Marburg, 1842, when he was twenty-five years old. In this work on secretion by the kidney, he developed the first physical theory of secretion of a gland. He deduced the method of the secretion of the urine from the structure of the kidney, and the physical forces which he thought must necessarily control them.

This work made him desire to know more concerning the action of physical forces on the passage of fluids through animal membranes, and led to important researches on

diffusion and osmosis. The exactness of the results were recognized by Ostwald.

He never lost interest in the original problem and a number of his students were assigned various phases of it during the succeeding years. An evidence of his open-mindedness is the fact that he was not disturbed by results which seemed to oppose his original view.

How Ludwig would have reveled in the clever technique displayed in the models and drawings of the kidney tubules, which have been developed in this laboratory by Dr. Huber.

Although emphasizing the important part played by blood pressure in the secretion of the urine, he proved experimentally that the pressure of the blood does not explain the secretion of the saliva, and his epoch-making discoveries with regard to the activities of the salivary glands began a new era in our knowledge of secretion processes. He proved that gland cells, like muscles, are capable of being awakened to activity by nerves, and become the seat of chemical changes, accompanied with the liberation of heat and the giving off of materials differing from those found in the blood.

Not less important were Ludwig's investigations of the interchange of oxygen and carbon dioxide gas between the blood and the tissues, and the blood and the air in the lungs. The blood-gas-pump devised by Ludwig and Setchenow in 1859, a new application of the Torricelli vacuum, proved the key to unlock many difficult problems. There followed many investigations by his pupils Schöffer, Holmgren, Preyer, Alexander Schmidt, giving the first measurements of the tension of the gases of the blood, and by Worm-Muller and Donders on the conditions which determine the tension.

Ludwig opened up still another line of work, the chemical changes occurring within special organs, when he found that it was possible to separate organs from the general circulation, and to study their metabolism by keeping them alive by artificially circulating defibrinated blood through them; *e. g.*, the heart of the frog was thus kept alive and acting for many days, and the effect of temperature, foods and drugs upon its activity were examined.

His studies into the formation of lymph, and the cause of its movement in the lymphatics, were of great value. According to Ludwig the plasma of the blood filters through the walls of the blood vessels, and so food materials are supplied to the various tissues. It is also the pressure of the blood which is the principal cause of the movement of the lymph stream. Where this is not sufficient, as in the case of the large cavities of the body, there are special pumping arrangements provided: in the abdomen and in the pleural cavities it is the respiratory movements of the diaphragm and of the chest walls which are responsible for the flow.

The conditions which determine the circulation of the blood always aroused his keenest interest, and it was because of his desire to grasp their significance that he was led to what has proved the most fruitful of his discoveries, the graphic method of recording physiological movements. In 1846, while still in Marburg, he studied the relation which exists between the movements of respiration and the pressure of the blood. He connected a U-shaped manometer tube partly filled with mercury, with an artery, but the movements of the column of mercury were so rapid and complex that the eye failed to retain them. It was then that he conceived the idea of recording the changes in pressure, and devised the kymographion. Let me quote his own words in his paper, "Beiträgen zur Kent-

niss des Einflusses der Respirationsbewegungen auf den Blut lauf in Arteriensystems," published in *Müller's Archiv,* 1847. "To obtain reliable figures under all circumstances by means of it (referring to Poiseulle's mercury manometer), and at the same time, time determinations for the duration and course of the different pressures, one places a rod-like float on the mercury, puts on the upper end a writing-point, and lets it draw the variations in pressure on a surface, which moves by the pointer with a constant velocity. In this way one obtains curves, the height of which is a measure of the blood pressure, and the width an indication of the time." Ludwig recorded the movements of the respiration and the oscillations of the blood pressure on the same paper simultaneously, and thus obtained curves which made possible an accurate comparison of the two series of events.

Although the graphic method was known at the beginning of the century to meteorologists and physicists (especially through the work of Thomas Young), it had been neglected and was carried again into physics and meteorology after the discovery of the kymographion. It has become, with its many modifications, an indispensable aid to the physiologist, pharmacologist, pathologist, clinician, and to experimental biologists and botanists. His pupil Angelo Mosso, the celebrated Italian physiologist, showed me the original tracing when I visited his laboratory in Turin. There is inscribed upon it the date, December 12, 1846, and notes concerning the experiment. It was the first time that the heart and respiration had spoken in their own language, and Ludwig in presenting it to Mosso wrote on the back—"I give to my friend Mosso for his collection, this first stammering of the heart and of the chest."

This was followed by researches into the structure and changes in form of the beating heart, which served to explain the true significance of the apex beat. He also did much to increase our knowledge of the cause of the first sound of the heart. All of these studies on the mechanics of the circulation naturally led Ludwig to a consideration of the means by which it is regulated, and so to a study of the nerves which act on the circulatory system.

The Weber brothers had discovered the effect of the vagus nerve to inhibit the heart. Schmiederberg, under Ludwig's guidance, 1866, discovered the accelerator nerve of the heart of the frog and of the dog, and in 1883, Wooldrich found centrifugal fibers to the heart of the dog, which altered the blood pressure without changing the rate of the beat. Bowditch, the best known of American physiologists, Luciani and Stienon, studied the effects of electrical excitations on the heart muscle, and ascertained a number of facts of theoretical importance to heart and muscle physiology.

Henle had observed the muscles in the walls of the blood vessels and Claude Bernard the existence of nerves which cause the constriction of certain blood vessels. It was left for Ludwig and Thiery to point out, 1863, the importance of these nerves in maintaining the tonus of the blood vessels, and consequently the blood pressure. Cutting the spinal cord was found to cause a fall, and exciting it a rise of blood pressure, without any change in the rate of the heart. They saw the vessels of the abdomen contract, and thought that the nerves ran in the splanchnic, a fact which Ludwig and Cyon proved in 1866. Moreover, during these latter experiments a nerve was found which ran from the heart to the medulla, the depressor nerve, which acts reflexly from the heart to dilate the blood vessels, and which protects the heart

from too great arterial blood pressure. Later, Ludwig and his pupils established more definitely the seat of the vaso-motor centers, and showed that the veins as well as the arteries of the portal system are under the control of nerves. Mall, now at Johns Hopkins, who worked with Ludwig in 1885, established this last fact.

It was Ludwig who started Mosso on the development of the plethysmographic method, by which the volume changes of organs under the influence of the alterations of the blood supply have been studied by many investigators, *e. g.*, Edmunds has found it of great value in work which he has been doing in the past years.

Ludwig's cleverness in inventing instruments required for his investigations is to be seen in the Stromuhr, by the use of which he was able to succeed where others had failed, and to measure the rate of the flow of the blood stream. By means of this he measured the rate of the output from the heart under varying conditions, and the amount of blood flowing through special organs when at rest and in action.

He was always deeply interested in reflex processes, and many experiments were carried on in his laboratory on the paths taken by nervous impulses along the white matter of the cord, summation processes, and the effect of local excitations and poisons. In addition, he caused many researches to be made on the special senses, sight, hearing and taste.

Investigations of a chemical nature were also made at his instigation, and von Frey has pointed out the difficulties which he must have encountered in directing such work, lying as it did outside of the fields with which he was most conversant. From the time that Ludwig and Alexander Schmidt found that easily oxidizable substances pass from the tissues into the blood, many such intermediate products were discovered in the chemical side of the laboratory, and their distribution through the body followed. Cloetta discovered the presence of inosit, uric acid, etc., in the animal body; calcium and phosphoric acid in the blood were measured; the lessening of glycogen in the "uberlebender" liver was noted; and the origin of jaundice studied. The method by which fats are absorbed, the streaming of fat in the lymphatics, the constitution and the fate of the fats entering the blood, all received attention. The digestion and absorption of proteins and sugars, and the changes which they undergo after entering the body were investigated, the structure of albuminous bodies being made the subject of special study by Drechsel.

An interesting discovery was made while the method of absorption of the digestion products of protein was being studied, namely, that albumoses if introduced directly into the blood act as poisons and deprive the blood of its power to coagulate. This observation gave a new impulse to the study of coagulation, and of the formed elements of the blood.

I am conscious of the incompleteness of this hasty summary of the work of Ludwig and his pupils.

Ludwig, himself, was deeply impressed with what had been accomplished, and the wide field of knowledge which had been opened up to man. I remember that he said the last time that I saw him, "What a pity that one must die just as it begins to be so interesting."

I can not close this paper without a few words concerning Ludwig's private life. He was no lover of forms and ceremonies, and counted of little worth the honors conferred by the so-called "great." I chanced to be present when a student called in dress coat and white gloves at the formal noon hour, as was the custom, to ask his

permission to enrole in his course of lectures. When the student addressed him as Herr geheimer Rath, Ludwig straightened up and corrected him, "Ich bin Professor."

In spite of his simple, genial manner, he had an innate dignity which always inspired respect. I can not imagine any one taking a liberty with him, certainly not a second time, for he could be cuttingly severe when he chose.

He was not only thoughtful and considerate of others, but his tender heart made him, although of necessity a vivisector, always careful to avoid the infliction of unnecessary pain. He saw to it that all experimentation on animals in his laboratory was performed in such a way that the suffering incurred should be the least possible. He was president of the Leipzig Society for the Prevention of Cruelty to Animals for twenty years, and did much to develop in the community a recognition of man's duty towards the animals dependent on him. The fact that he held this position for so long, shows how thoroughly this side of his character was recognized by his fellow citizens.

In his young days he was an active polemiker, and in that connection could use right hard words, but one never noticed in his controversies anything that pointed to an overestimation of self; the contest was simply the expression of his inner conviction that the way that the new physiology had chosen was the right way, and that one must vigorously fight the methods of dilettanteism, which, without regarding the true content of the question at hand, would escape the difficulties, to reach results which at first glance were striking.

Every new advance which promised to open the doors of nature's secrets, regardless of where and by whom they were made, was greeted not merely with warmth, but with enthusiasm. M. Chauveau, when president of the Société de Biologie of Paris, referring at one of its meetings to the loss which science had suffered in Ludwig's death, said, "Ludwig, du rest, etait animé du sentiments de l'equité porté au plus haut dégré; il n'a jamais ménagé l'expression de son admiration à ceux de nos compatriotes qui en étaient dignes."

Ludwig's interests were not merely scientific. He possessed a remarkable fund of information on the greatest variety of subjects, and whether he spoke of music, art, industrial and political conditions in other lands, of science or philosophy, his point of view was always original and suggestive. He had a keen sense of humor, and in the midst of a conversation of grave interest he would introduce an amusing story which would illustrate the point under consideration without breaking the thread of thought. An admirable storyteller, he rarely told a story for the story's sake; gifted beyond most men as a speaker, he was a good listener; in short he had the ability, possessed by so few, of leading a conversation so as to bring out the best from others.

Much of his power over his pupils was based upon his unaffected regard for them as individuals. He entered into their lives as only a friend can do, and continued his interest in them and their work long after they had left the institute. He wrote a charming letter, and found the time to answer his old pupils when, working under unsympathetic conditions, they turned to him for advice and new inspiration. I hold in my hand a photograph which I value greatly, and which bears a characteristic inscription: "Could I but spring and swim like the third in our league, I would soon croak 'Good morning' to you and your dear wife in New York. Oh they were good days. Your former teacher." They were good days.

In February, 1895, two months before he

died, when he was seventy-eight years old, Professor Ludwig wrote to me to say that he would take into his laboratory a young American whom I had recommended. Beginning the letter with a charming, fanciful sketch of the way my new house must look and the wish that he might be there with us, he ran into a soberer vein and wrote:

> Destiny has conferred on us professors the favor of helping the responsive heart of youth to find the right path. In the seemingly insignificant vocation of the schoolmaster there is enclosed a high, blessed calling. I know no higher. In its fulfilment you will be the happier the more you yourself grow in knowledge and power of thought, the more you endeavor to be suited to the profession. How glad I am of your present and future happiness.

Ludwig died in his seventy-ninth year, in Leipzig, April 27, 1895. His wife wrote us:

> Our daughter had come to us to help care for her father, and we were both by him day and night. Seven weeks he lay sick, but his mind was always clear. Only a few days before his death his thoughts were busied with a paper which he wished to write on his dead friend Helmholtz. On the last evening he still asked us about many things in which he was interested, then complained of great fatigue and so softly slept. The hastily called physician could only tell us that a sudden heart failure had quickly and painlessly ended his life.

No better words can be spoken at the end of an account of Ludwig's life, than those which he used at the close of his Gedächtnissrede for Ernst Heinrich Weber:

> Now that he has departed from us, he has left us a rich heritage, but inestimable good has sunk into the grave with him. The one on whom his soulful eyes rested, who listened to the flow of his thoughtful words, who felt the pressure of his hand, will always long for him. Yet not only the friend, each one who in life and in science came in contact with his power, will mourn the death of a man, in whom were mingled in complete harmony, a spirit as clear as his and a nature of such richness.

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ANIMAL LIFE AS AN ASSET OF NATIONAL PARKS[1]

THE argument most frequently urged in favor of national parks is that they provide on a large scale for the protection of forest areas, and thereby ensure the transmission of a maximum water supply from the wooded tracts to the needy lands below. Attention has also been called to their value as refuges for wild life—particularly where the animals to be conserved are useful for game or food. The strict protection they afford enables the birds and mammals within their boundaries to reproduce at a maximum rate, and the surplus thus created, spreading outwards into adjacent unprotected areas, helps to make up for the depletion caused there by excessive hunting. The points mentioned above are fairly obvious. But national parks have other less generally recognized advantages, and among these we consider their potential uses as places for recreation and for the study of natural history, especially worthy of notice. We will here lay particular emphasis on their recreative value because this phase seems to have hitherto been treated only in a cursory way, and with an air of hesitancy, as if it were hardly deserving of practical consideration.

The term recreation is currently applied to any temporary change of occupation that calls vigorously into play latent or seldom used faculties of the mind and body. It is the purpose of this change to restore to the human organs the normal balance which special or artificial conditions of life disturb. As physiologists have long recognized, the interdependence of the various bodily functions is such that the neglect of one is bound to have its effect on the others, and complete health can only be attained when every function is given its adequate share of exercise. In view of this fact

[1] Contribution from the Museum of Vertebrate Zoology of the University of California.

and of the general character of urban life at present, it would seem that the type of recreation most urgently needed by the majority of people to-day is to be found in the open country. The relatively abrupt changes coincident with modern civilization have seriously interfered with the fine adjustments acquired by the human body in the course of long ages; and the modern business man, who may be regarded as the final and typical product of these changes, can now obtain rest in its fullest sense only by resorting for several weeks in the year to the open country or mountains. There he may find entire relief from the nerve-racking drive of city life, and be brought once more into contact with primitive conditions. There he may have an opportunity of reawakening his dormant faculties and of "resetting" his physical "tone," by effecting a readjustment of physiological interrelations. One of the greatest needs of city dwelling people is to develop objective interests; "to get out of themselves," as the phrase goes; and a frequently effectual means to this end is a keen interest in outdoor things, encouraging, as it must, a healthy manner of living, an unconfined habit of observation, and a mood unaffected by the nervous tension so peculiar to town life.

If this be true, it follows that the best recreative elements in nature are those which most infallibly tend to revive our atrophied faculties and instincts. Among them the following are important. First: either perfect quiet, or an absence of all save primitive and natural sounds, such as those caused by the wind in the trees, by running or falling water, or by singing birds. Second: landscapes that relieve the eyes from close work by offering distant views, quiet harmonies of color, and a quiescent atmosphere, varied by occasional touches of movement in such objects as running or falling water, scurrying squirrels, or birds in flight. Third: accessible mountains, which encourage climbing and allow the visitor to combine the exhilaration of overcoming obstacles with the physical exercise attending the woodsman's mode of travel. Fourth: natural phenomena that make a purely intellectual or esthetic appeal, as do the conflicts between the great insentient forces of nature, the processes of geological upbuilding and destruction, the intimate inter-relations of plants and animals, and the contentions for mastery that are forever recurring throughout the whole realm of living things. We believe the last, the mental appeal, to be the element of greatest recreative value in nature, but the other three are only of slightly less importance.

The question may now be raised: "Can national parks meet these requirements any more fully than other uncultivated areas?" With the country in its present half developed state the objection has a certain degree of force. In this era one is inclined to think of the unprotected wilds as the silent, virginal and unspoiled regions of the earth, and to regard national parks as comparatively well-peopled areas where plants and animals are subjected to artificial restrictions. To a limited extent, and for the moment, this impression is a true one. But the objection will have less force in the course of a few years, and none whatever if by that time the full recreative possibilities of the parks have been realized. For the commercial exploitation of nature that is now going on so rapidly elsewhere, is daily making the conditions we have described harder to seek, and is confining them more and more closely to the park areas, where the administrators should be taking measures to propagate and conserve them. By this we do not mean that the parks should in any way be conventionalized or transformed. On the contrary, it is their chief function to prevent just that disfigurement of the face of nature by industrial machinery which is being carried on at such a disastrous rate in other localities. We mean rather that the ideal recreative conditions now to be found in them should be preserved, that all factors disturbing to these conditions should be excluded, and that the artificial elements required for the practical work of administration should be disguised or beautified past offense.

Let us, however, take up these points in greater precision and detail. The first neces-

sity in adapting the parks for recreative purposes is to preserve natural conditions. In this respect a national and a city park are wholly different. A city park is of necessity artificial, in the beginning at least when the landscape is planned and laid out; but a national park is at its inception entirely natural, and is generally thereafter kept fairly immune from human interference. Herein lies the feature of supreme value in national parks: they furnish samples of the earth as it was before the advent of the white man. Accordingly, they should be left in their pristine condition as far as is compatible with the convenience of visitors. All necessary roads, trails, hotels and camps should be rendered inconspicuous, or, better still, invisible from the natural points of vantage in the parks. Another reason for retaining primitive conditions is that natural scenery unmarred by man is one of the finest known sources of esthetic pleasure. Any attempt to modify the appearance of a national park by laying out straight roads, constructing artificial lakes, trimming trees, clearing brush, draining marshes, or other such devices, is in the worst of bad taste.

As has already been intimated, the animal life of the parks is among their best recreative assets. The birds and mammals, large and small, the butterflies and the numerous other insects, even the reptiles and amphibians, are of interest to the visitor. As a stimulant to the senses of far sight and far hearing, faculties largely or altogether neglected in the present scheme of civilization, they are of no less consequence than the scenery, the solitude and the trails. To the natural charm of the landscape they add the witchery of movement. As soon as the general surroundings lose their novelty for the observer, any moving object in the landscape will catch his eye and fix his attention. People will walk miles and climb thousands of feet to secure a good view of falling water, and this desire for movement is even more completely satisfied by the sight of animals in motion. The moving deer, passing within range of the stage-coach, rouses exclamations of surprise and delight. Eagles and pigeons in flight overhead readily claim the traveler's notice, and the smaller birds often mingle the fascination of sprightly movement with that of bright color and pleasing song. Considering the predilections of the average visitor, we should perhaps regard these last as the most indispensable creatures in the parks.

The interest of moving objects depends upon a number of elements other than movement, among which their color, and especially their size, is important. The chipmunk is more attractive than the ground squirrel, primarily because its movements are more rapid, and secondly because of its more brightly colored markings. But when movement and color are equal the average observer's selection seems to have a quantitative basis, though the rarity of the object, and its romantic or other associations affect the equation. A bear or a deer will elicit more interest than a smaller mammal, even though the latter be of a rarer species. There are exceptional cases where an animal's extreme rarity will make it of exceptional interest in spite of its inferior size, but in general the larger species are the more rare, as they are the first to disappear before human invasion. They have therefore a double claim to consideration, and measures should be taken to prevent their numbers from diminishing. After the visitor's initial curiosity has been aroused and his powers of observation developed, he may be trusted to give a closer study to the smaller species.

To realize the greatest profit, therefore, from the plant and animal life of the parks, their original balance should be maintained. No trees, whether living or dead, should be cut down, beyond those needed for building roads, or for practical elimination of danger from fire. The use of wood for fuel in power stations, or even for cooking and heating in hotels and camps, is made unnecessary by the abundant supply of water power everywhere available, and this may be utilized without marring the scenery in the slightest. Dead trees are in many respects as useful as living, and should be just as rigorously protected. The brilliant-hued woodpeckers that render such effective service in ridding the living trees of destructive insects depend in part on

dead trees for a livelihood. In these they find food during the colder months of the year, when the insects elsewhere are in great scarcity. Here, too, they excavate their nesting holes. Some of the squirrels and chipmunks also seek shelter in dead or partially dead trees. Even down timber is an essential factor in upholding the balance of animal life, for fallen and decaying logs provide homes for wild rats and mice of various kinds, and these in their turn support many carnivorous birds and mammals, such as hawks, owls, foxes and martens.

No more undergrowth should be destroyed than is absolutely necessary. To many birds and mammals thickets are protective havens into which their enemies find it difficult to penetrate. Moreover, the majority of the chaparral plants are berry-producers and give sustenance to wild pigeons, mountain quail, robins and thrushes, and to chipmunks and squirrels —this, too, at the most critical time of the year, when other kinds of food are scarce or altogether wanting. The removal of such plant growth will inevitably decrease the native animal life. If any change is to be made at all, it would, indeed, seem preferable to increase the number of indigenous berry-producing plants, especially in the vicinity of camps and buildings. This would compensate for the shrubbery lost in constructing roads and buildings, and would also serve to attract berry-eating species to the points where they might be seen by the largest number of people.

It goes almost without saying that the administration should strictly prohibit the hunting and trapping of any wild animals within the park limits. A justifiable exception may be made when specimens are required for scientific purposes by authorized representatives of public institutions, and it should be remarked in this connection that without a scientific investigation of the animal life in the parks, and an extensive collection of specimens, no thorough understanding of the conditions or of the practical problems they involve is possible. But the visiting public should be warned against injuring, and even against teasing or annoying any of the mammals, against destroying lizards and snakes (except the rattlesnake), and against disturbing the nests of birds, or their young. In the last instance a very slight disturbance will often lead to subsequent destruction. The principle underlying these suggestions is apparent. The native complement of animal life must everywhere be scrupulously guarded, particularly along the most traveled roads and paths, where the animals are likely to be observed by the greatest number of visitors. It is there that each individual animal is of highest intrinsic value from an esthetic viewpoint.

As a rule predaceous animals should be left unmolested and allowed to retain their primitive relation to the rest of the fauna, even though this may entail a considerable annual levy on the animals forming their prey. We, as naturalists, are convinced that the normal rate of reproduction among the wild non-predaceous species, such as mice and squirrels, has adjusted itself to meet a certain annual draft on their population by carnivorous enemies. Another point worth emphasizing is that many of the predatory animals, like the marten, the fisher, the fox and the golden eagle, are themselves exceedingly interesting members of the fauna, and as their number is already kept within proper limits by the available food supply, nothing is to be gained by reducing it still further. Here again may be recognized the special and intimate relations everywhere existing among the various plants and animals.

The rule that predaceous animals be safeguarded admits of occasional exceptions, according to season, place and circumstance. Coyotes and bob-cats, especially the latter, when they are numerous, are likely to kill a great many grouse, quail, rabbits and squirrels. Cooper and sharp-shinned hawks, and, to a lesser extent, blue jays, are proven menaces to small birds, and it might be advisable to reduce them in the neighborhood of camps and much-traveled roads. Caution, however, should be exercised in doing so, and no step taken to diminish the numbers of any of these predators, except on the best of grounds.

We would urge the rigid exclusion of domestic cats and dogs from national parks. Cats are the relentless enemies of small birds; they are forever on the alert, and in ninety-nine cases out of a hundred can not be trusted, however well fed they may have been at home, to let birds alone. The fact that they readily go wild, that is, quickly revert to a feral state, makes it all the more important that they be kept out of unsettled regions. To admit them would mean adding one more predator to the original fauna, and this would tend to disturb the original balance, by making the maintenance of a normal bird population difficult or impossible.

Equal vigilance should be used to exclude all non-native species from the parks, even though they be non-predaceous. In the finely adjusted balance already established between the native animal life and the food supply, there is no room for the interpolation of an additional species. If pheasants be introduced, and allowed to become established in the wild, the native quail and grouse will inevitably suffer from competition with them at the season of minimum food supply, and will be numerically reduced in consequence. The same is true of elk in competition with the native deer, and of many imported small birds in rivalry with the native varieties. In the latter connection we need only mention the well known instance of the English sparrow. Cattle and sheep are also of importance as elements hostile to natural conditions, but their destructiveness has already been emphasized by foresters.

Thus far we have laid chief stress on the importance of the national parks to recreation, and have shown the necessity, in adapting them for this purpose, of retaining the original balance in plant and animal life. But the same necessity attaches to their adaptation for another end, hardly less important than recreation, namely, research in natural history. As the settlement of the country progresses and the original aspect of nature is altered, the national parks will probably be the only areas remaining unspoiled for scientific study, and this is of the more significance when we consider how far the scientific methods of investigating nature then obtaining will be in advance of those now applied to the same study.

As a final requirement, we would urge that provision be made in every large national park for a trained resident naturalist who, as a member of the park staff, would look after the interests of the animal life of the region and aid in making it known to the public. His main duty would be to familiarize himself through intensive study with the natural conditions and interrelations of the park fauna, and to make practical recommendations for their maintenance. Plans to decrease the number of any of the predatory species would be carried out only with his sanction and under his direction. He would be able to establish and supervise local feeding places for birds and mammals during the tourist season, and could do this without in any serious degree altering natural conditions. His acquaintance with the local fauna would enable him to communicate matters of interest to the public in popularly styled illustrated leaflets and newspaper articles, on sign posts, and by lectures and demonstrations at central camps. He would help awaken people to a livelier interest in wild life, and to a healthy and intelligent curiosity about things of nature. Our experience has persuaded us that the average camper in the mountains is hungry for information about the animal life he encounters. A few suggestions are usually sufficient to make him eager to acquire his natural history at first-hand, with the result that the recreative value of his few days or weeks in the open is greatly enhanced.

We have attempted in these columns to emphasize the value of national parks as places for recreation and for scientific research, two of their uses that have been rather commonly overlooked, and to show the importance in both connections of the animal life they contain. If the reasons and instances we have adduced are valid, there is surely ample warrant for saying that the animals in the parks should be given more care and attention than

they are now receiving, and that they should be conserved and utilized to a fuller extent.

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Tracy I. Storer
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THE REVIVAL OF INTEREST IN BIRD ANATOMY AT THE UNITED STATES NATIONAL MUSEUM

Very well do I remember when the foundation was laid for a department of comparative anatomy at the United States National Museum. It took place some time along in the early eighties, when Professor Baird's splendid régime was at its height and zoological work was at its best at the Smithsonian Institution. My early papers on the osteology of birds had appeared in Hayden's Twelfth Annual of the U. S. Geological and Geographical Survey of the Territories, and, owing to a fulfilment of a promise made by the then surgeon-general of the army, I found myself in the position of curator of the department of comparative anatomy at the old Army Medical Museum on Tenth Street in Washington. Naturally, I desired to follow up my work on the osteology of birds and upon vertebrate anatomy generally. This impulse led me to obtain Professor Baird's permission to examine what the collections at the National Museum contained in the way of material for descriptive purposes, and to look into the matter of the possibility of publishing researches along such lines.

Professor Baird was a man who took an intense personal interest in the labor of all his curators, and it was his habit every day, when he could afford the time to do so, to make a round of the institution for the purpose of encouraging them in their investigations and to learn whether there was anything, in any particular case, that a curator needed to push his investigations forward. He no sooner noticed my interest in bird anatomy than he opened up the way to make it count for science, and for the advancement of work in that particular field. He immediately established a base for such operations by founding a new position for those not on the regular museum staff, but who were devoting a large share of their time to scientific investigation, with the view of publishing the results of their studies. The late distinguished Dr. Theodore Nicholas Gill and myself were the first two zoologists appointed by Professor Baird to become co-workers under him as "associates in zoology" on the staff of the institution. Shortly after this event, I undertook to examine the collection there of such material as illustrated the morphology of birds. The alcoholic collection contained many specimens of great value; but what interested me most at that time was the collection of bird skeletons. This consisted of a very remarkable, not to say heterogeneous, lot of avian skeletons, none of which were scientifically prepared. Many were roughed out; a large array of them had been cleaned up by the "sand fleas" of the seas that wash our Alaskan possessions, and, finally, not a few of them were sterna of birds *saved* by bird collectors all over the country while skinning specimens for their collections. To show how valuable some parts of the material were, I may say that, in one little pasteboard box, I found the original chicken skulls used by Charles Darwin in Volume One of his "Animals and Plants Under Domestication" (Figs. 34, 35 and 36), they evidently having been presented to the Smithsonian either by himself or by Mr. Tegetmeier. (How long they had been in that little box I do not know; at this writing they have been placed in a special case in one of the exhibition halls of the new National Museum!)

A great mass of these skeletons had been collected by our northern explorers, as Dall, Elliott, Bean, Nelson, Turner and others, and were in a fairly good condition. All this material was in "original packages," that is, in any old receptacle the collector could lay his hands upon in the field—chiefly empty cigar-boxes, all sorts of pasteboard boxes, boxes that had held ammunition for collectors, etc. All had been stored away and was covered with the dust of time. However, I gave the lot a preliminary going over, and Professor Baird promptly assigned to my department—the department of comparative anatomy—an old

lady with a feather duster, requesting me to make known to him anything else I might require. My assistant immediately started in with the duster, and the material was brought to light. A request of mine for an assorted lot of cardboard boxes was favorably considered early in my work; in due course the collection of bird skeletons was *boxed,* the specimens labeled, and the whole made accessible for the use of students.

At this stage of the proceedings a board appointed by the government found me unfitted for promotion (Doctor Coues was also at work in the Smithsonian Institution), and I was ordered to New Orleans. Dr. Lucas succeeded me; and through his splendid energy and genius, the department of comparative anatomy was placed on a sound basis, with a wealth of material of all kinds, elegantly exhibited and cased. Indeed it was, at the close of his régime, the envy and admiration of all the scientific institutions in the world that knew anything about the department. After Dr. Lucas's connection with the National Museum was severed, and I had been, upon second thought of the government, found fitted for promotion and duly ordered *west,* the department of comparative anatomy seemed to slowly dwindle away, finally being split up among the various divisions of the National Museum. Eventually the bird alcoholics and skeletons drifted into Professor Ridgway's division, and, through no fault of his, a long period of *statu quo ante lucasum* set in.

During my seven years' study of crime and human psychology and morphology in New York City I wrote but few papers on the osteology of birds, and these were based principally on material sent me by the Bureau of Science at Manila and the Zoological Society of London. Then, when I returned to Washington to live, my work in vertebrate anatomy was more actively taken up, as I had determined it should be before the sojourn in New York was decided upon. At the end of four or five years or more, when my published memoirs in that field began to run up into the dozens, and the figures illustrating them into many hundreds, I found that I was deeply indebted to the United States National Museum for the loan, at different times, of a great number of bird skeletons used in that particular field of my work. The assistance rendered me by that institution has proved invaluable, and the aid given by Professor Ridgway, and by Dr. Richmond and his assistants, has been and is most thoroughly appreciated.

For a year or more past I have observed, without commenting upon the fact, that there has been a slow but steady improvement upon the former condition of things in the section containing the boxed collection of bird skeletons. Notwithstanding his arduous duties as assistant curator of the division of birds, Dr. Richmond has made a requisition for a series of cases to contain the collection, and these are now in use in a fairly convenient place in the department. A "cleaning up" gradually followed, and a raking together of all the bird skeletons that were in various rooms in the museum. These were placed in trays, to be eventually cleaned and boxed. But what was to be done with them? Professor Ridgway, deep in completing his great work on "The Birds of North and Middle America," could not, even had he wished to do so, think of giving the matter a moment's attention, and Dr. Richmond has as much as he can possibly handle by attending to the affairs of one of the most important departments of the museum—the division of birds, with its enormous collection of bird skins, with its library and correspondence, and with other duties too numerous to mention.

At this juncture, through fortunate circumstances, Mr. Alex. Wetmore, of the Biological Survey, became interested in the matter, and through a mutual cooperation of all concerned, he arranged to put the collection of bird skeletons into the various cases supplied for them, and to settle the material in place as best he could, after his duties at the survey were over for the day. This has been accomplished as far as could be expected under the circumstances, and Mr. Wetmore has emphasized the interest he has taken in the new order of things by publishing a number of

brief though important contributions to bird anatomy.

The interest of the veteran ornithologist, Mr. Oberholser, has also been aroused, and therefore it is likely that additional good results will be forthcoming.

Thus matters seem to stand at the present time, and there is hardly any room for doubt but what an added interest is being taken in this most important branch of biology. If it be genuine and progressive, American science is to be heartily congratulated; should it lead to the appointment of a curator of the department of bird anatomy—of one who understands the *aims* and *needs* of such a department and who has the *energy* to make it in time what it should be, I feel sure that there are congratulations in waiting when such a happy sequel materializes.

Personally, I have always regretted that the division of comparative anatomy of the U. S. National Museum was dissolved, as this was a *prima facie* evidence of a stage of decadence setting in, in a very vital part of the scientific organism. It should be put on foot again in full force, and brought up to the standard where it properly belongs. We are terribly wasteful in such matters; the absence of a division of comparative anatomy in the United States National Museum can only be equaled by the present and corresponding deficiency in the matter of a prosectorial department connected with the National Zoological Park at Washington, where animals frequently die and no attempt is made whatever to examine and report upon their anatomy.

America is coming to the front in many things now besides in what the dollar means, and it should be the aim of science to look well to it that this field is brought properly into line.

R. W. Shufeldt
Washington, D. C.

SCIENTIFIC NOTES AND NEWS

Dr. Percival Lowell and Professor F. Schlesinger have been elected honorary fellows of the Royal Astronomical Society of Canada.

Professor S. W. Williston, of the department of geology and paleontology of the University of Chicago, has been appointed director of the Walker Museum.

Professor J. G. Sanders has resigned as state entomologist of Wisconsin to become economic zoologist of Pennsylvania. His work at Harrisburg begins on September 16, 1916. Dr. S. B. Fracker has been appointed acting state entomologist of Wisconsin by the commissioner of agriculture, and will have charge of the work of the state entomologist's office until a successor to Professor Sanders is appointed.

C. H. Hadley, Jr., of the department of entomology of Cornell University, has been appointed extension entomologist at the Pennsylvania State College.

Dr. Robert Armstrong-Jones has retired from the post of medical superintendent of the London County Lunatic Asylum. A special pension has been awarded to him on the recommendation of the Asylums Committee of the London County Council.

Dr. Linsly R. Williams, deputy commissioner of the New York State department of health, has been appointed by Governor Whitman to conduct an investigation into the proposed building of a garbage disposal plant for New York City on Staten Island.

The Mississippi Valley Conference on tuberculosis will be held at Louisville, Ky., from October 4 to 6, under the presidency of Walter D. Thurber, of Chicago.

Mr. Wellington Jones, of the department of geography, University of Chicago, is traveling in eastern Asia in preparation for the giving of courses in the geography of Asia.

The faculty of medicine of the University of Toronto, which suffered from the enlisting of professors for service in connection with the University Base Hospital, will be strengthened by the return of Dr. John J. MacKenzie, professor of pathology and bacteriology, and Dr. Benjamin P. Watson, professor of obstetrics and gynecology.

During July the botanical laboratory of the Purdue Experiment Station at Lafayette, Ind., had the services of Dr. Frank D. Kern and Professor C. R. Orton, of the Pennsylvania

State College; Dr. F. D. Fromme, of the Virginia Polytechnic Institute, and Mr. C. A. Ludwig, research student of the University of Michigan, all former members of the laboratory staff. They came to assist in the preparation of the remaining parts of the Uredinales for the "North American Flora."

PROFESSOR LAWRENCE MARTIN, of the University of Wisconsin, assisted by Mr. F. T. Thwaites, had a class of 22 men doing field work in geology and geography in the Devil's Lake region (Wis.), during the month of August.

WE learn from the *Journal* of the American Medical Association that the International Health Board has taken up the consideration of the subject of malaria under the phases of geographic distribution and district of infection. Two sets of experiments to test the practicability of malaria control are being carried out; one, the detection of the carriers and freeing them of the parasites, and the other a combination of control measures. The first experiment is being carried out in Bolivar County, Miss., under the administration of the Mississippi Department of Health, with Dr. Walter S. Leathers, University, as administering director and Dr. Charles C. Bass, New Orleans, as scientific director. The field force and microscopists have received their technical training in the laboratory of Tulane University. The second series of experiments is being carried out in Arkansas in cooperation with the United States Public Health Service, under the charge of Surgeon Rudolph H. von Ezdorf.

THE annual New England forestry conference under the auspices of the Society for the Protection of Forests and the New Hampshire State Forestry Commission, was held at the Crawford House, last week. At the formal opening of the conference addresses were made by William L. Hall, chief purchasing agent of the government under the Weeks' Act, and by William P. Wharton, of Groton. At the general sessions Professor Filibert Roth, director of the forest school in the University of Michigan, presented a paper showing how an owner of a wood-lot may estimate the value of his woods. There were addresses by Arthur A. Shurtleff, of Boston; Dr. B. E. Fernow, president of the Society of American Foresters, and dean of the forestry school of the University of Toronto, and by Professor James A. Toumey, director of the Yale Forest School.

OFFICERS of the Society for the Promotion of Engineering Education elected at the annual meeting are: *President,* G. R. Chatburn, University of Nebraska; *First Vice-president,* Hollis Godfrey, Drexel Institute; *Second Vice-president,* W. M. Thornton, University of Virginia; *Secretary,* F. L. Bishop, University of Pittsburgh; *Treasurer,* W. O. Wiley, New York, N. Y.; *Members of the Council to serve for three years,* E. J. McCaustland, University of Missouri; F. G. Higbee, State University of Iowa; R. W. Gay, Mississippi College; T. E. French, the Ohio State University; A. H. Blanchard, Columbia University; A. A. Potter, Kansas State Agricultural College; Wm. H. Browne, Jr., North Carolina College.

DR. CHARLES R. BARDEEN, professor of anatomy and dean of the medical school of the University of Wisconsin, delivered an address on August 31 before the graduate school of medical sciences of the University of Illinois on "Study of the Anatomy of the Heart in the Living by the Use of the Roentgen Ray."

THE United States Civil Service Commission announces an examination for scientific assistant, for men only, on October 4, to fill vacancies in the positions of scientific assistant and field assistant at $900 to $1,400 per annum in the Bureau of Fisheries, Department of Commerce.

THE Wellcome Historical Medical Museum, London, will be closed until September 30, when it will reopen with a loan exhibition illustrating the folk-lore of London, including medical charms, amulets and other objects found to have been used by the superstitious in connection with the cure and prevention of disease.

THROUGH a gift from Sir Charles Parsons the British National Physical Laboratory has

made arrangements, at the request of the Röntgen Society, for the examination of materials employed for the protection of X-ray workers.

We learn from the *British Medical Journal* that the late Miss Mary Hamilton, of Glasgow, left £165,000 to Scottish institutions, including £30,000 to the Western Infirmary, Glasgow, for a Hamilton ward and £7,500 for ordinary purposes; £10,000 to the Glasgow Royal Infirmary for ordinary purposes; £7,500 each to the Glasgow Hospital for Sick Children and the Edinburgh Royal Infirmary; £7,500 to the Victoria Infirmary, Glasgow; £5,000 to the Royal Edinburgh Hospital for Incurables; and £1,000 each to the Glasgow Ophthalmic Institution, Glasgow Hospital for Diseases of the Ear, Nose and Throat, and the Glasgow Eye Infirmary.

It is stated in *Nature* that at the meeting of the City of London Court of Common Council, on July 20, it was resolved: (1) That in view of the great advantages which would accrue to British commerce in foreign markets by the use of the decimal system of coinage and weights and measures, in the opinion of this court it is desirable that steps should be taken to ensure its immediate introduction, so that it may be already in operation at the conclusion of the war; (2) that in view of the fact that England and the Allies are entering into arrangements for concerted action with regard to future trade matters, it would be of immense value if one language could be recognized as the commercial language, and taught in all schools, here and abroad. By so doing, English, French, Russian, Esperanto or any other language decided on would form the basis of communication on business matters throughout the world.

At the fifty-third meeting of the American Chemical Society, to be held in New York City during the last week of September, the division of biological chemistry will hold, on Wednesday morning, September 27, a joint session with the division of physical and inorganic chemistry to discuss theoretical colloid chemistry. On Thursday morning a joint session with the division of industrial chemists and chemical engineers will be held to discuss the practical applications of colloid chemistry. On Friday and Saturday mornings the division of biological chemistry will meet for the presentation and discussion of the papers of its regular program. Papers on colloidal chemistry are as follows:

D. B. Lake, "Irreversible Absorption of Dyes."

A. B. Macallum, "Surface Tension of Protoplasm."

G. H. A. Clowes, "Phase Relations in Biological Systems."

W. D. Bancroft, "Displacement of Equilibrium of Catalytic Agents."

E. F. Farnan, "Stabilization."

E. L. Mack, "Showerproofing."

J. M. Ball, "The Photographic Developer."

Irving Langmuir, "Structure of Liquids with Particular Reference to Surface Tension."

T. R. Briggs, "Electrical Endosmose."

Charles Baskerville, "Refining of Oils."

C. J. Fink, "Relation between Chemical Composition and Electrical Resistance."

T. R. Briggs, "Paints."

L. A. Keane, "Yellow Bricks."

D. Spence, "Vulcanization of Rubber."

A. W. Davison, "Adsorption of Chromium Hide Powder."

A. W. Fisher, "Adsorption of Sulphuric Acid by Hide Powder."

Clifford Richardson, "Asphalt."

L. A. Keane, "Plaster of Paris."

Jerome Alexander, "Selective Adsorption and Differential Diffusion."

H. W. Gillett, "Emulsion and Suspensions with Molten Metals."

C. L. Parsons, "The Purification of Kaolin."

W. D. Bancroft, "Fritting and Fusing."

UNIVERSITY AND EDUCATIONAL NEWS

The University of Chicago has received a fund to create the Edith Barnard Memorial Fellowship in Chemistry. Miss Barnard, who was instructor in the department of chemistry when she died, had received three degrees in science from the university, that of bachelor of science in 1903, that of master of science in 1905, and that of doctor of philosophy in 1907; and she had been connected with the department for ten years.

BEREA COLLEGE announces a gift of $10,000 from the late James Talcott, of New York City, received shortly before his death. This gift was part of a total pledge for $40,000 for the erection of a girls' dormitory, which will be ready for occupancy on January 1.

THE New York School of Dental Hygiene has become allied with the new Columbia University School of Dentistry and the College of Physicians and Surgeons. The school will open on September 27, classes being held in the Vanderbilt Clinic.

IRVING H. BLAKE, A.M. (Brown, '12), instructor in the Oregon Agricultural College, has been appointed instructor in the department of zoology, Syracuse University.

MR. CHARLES COLBY, recently of the Peabody College for Teachers, Nashville, Tenn., has become instructor in geography at the University of Chicago.

AT the University of Chicago, Anton Julius Carlson, of the department of physiology, and Charles Manning Child, of the department of zoology, have been promoted to professorships. Lee Irving Knight, of the department of botany, has been promoted to an assistant professorship. New appointments are: Ernest Watson Burgess, of Ohio State University, to be assistant professor in the department of sociology and anthropology; Professor Jean Piccard, of the University of Lausanne, Switzerland, to be assistant professor in the department of chemistry, and Dr. W. B. Sharpe and William E. Cary, to be instructors in the department of hygiene and bacteriology.

DISCUSSION AND CORRESPONDENCE

PRESIDENT WILSON'S SCIENTIFIC APPOINTMENTS

THE two articles in SCIENCE of August 25, 1916, on "Scientific Appointments under the Government" and "President Wilson's Scientific Appointments" are interesting and suggestive, but not entirely convincing. They do not fully cover the question; the writers were apparently not familiar with a number of facts which have a very important bearing upon the point at issue. In fairness to all concerned it is necessary to call attention to a few scientific appointments made by the Wilson administration about which the writers failed to enlighten the readers of SCIENCE and *The Scientific Monthly*.

In the first place, it has been generally understood (and even claimed by some of the parties interested) that the original administration slate contemplated the appointment of E. Lester Jones to the position of commissioner of fisheries. That this slate was broken is much to the credit of the American Society of Naturalists and the American Society of Zoologists. But what followed? The president immediately appointed Mr. Jones deputy commissioner of fisheries. That position, in many respects, even more important to science than that of the commissionership itself, and which should have been filled only upon the recommendation of the commissioner, was at once filled by the appointment of Mr. Jones. The commissioner of fisheries was not even consulted. He was completely ignored by the president and the secretary of commerce not only in this case but in other important appointments in the bureau of fisheries, a few of which may be mentioned. One of the first was the appointment, without even consulting the commissioner of fisheries, of a young man as private secretary to the commissioner. It would seem that the chief of an important bureau should be permitted to select his own private secretary, the position being so distinctively personal and confidential. The young man appointed was, it is understood, from the home town of John H. Rothermel, at that time a congressman from Pennsylvania and chairman of a committee of the House that had been for some years conducting certain fur-seal hearings. The young man was neither a stenographer nor a typewriter (it was said he was a plumber). It was said at the time (and there is every reason to believe it was true) that he was appointed as a spy to keep Rothermel and Henry W. Elliott informed as to the commissioner's relations to fur-seal matters, in which Rothermel at that time was very active—so active, indeed, that at the next

election, he was unable to explain certain charged irregularities and his constituents declined to return him to congress.

Another flagrant violation of the principles of the civil service and a total disregard of fitness was the appointment of one H. O. Smith, of Palestine, Illinois, as chief Alaska salmon agent. This appointment was made without consulting the commissioner of fisheries or the chief of the Alaska fisheries service, and after the secretary of commerce had assured the commissioner of fisheries that he would promote to the position the assistant Alaska salmon agent, Mr. Ward T. Bower, a thoroughly competent and experienced man. H. O. Smith openly claimed that his appointment was made at the instance of Senator James Hamilton Lewis, of Illinois.

The duties of the Alaska salmon agent, like those of a deputy commissioner of fisheries, are highly technical, and require special knowledge and experience of the fisheries. Neither Mr. Jones nor Mr. Smith possessed even elementary knowledge of fishes or fisheries; it was apparent that neither could tell a salmon from a sucker. Each of them made at least one tour of inspection of the Alaska fisheries, bringing discredit upon the bureau wherever they went, so lacking were they in knowledge or appreciation of the problems of the fisheries. The voluminous and profusely illustrated report by the deputy commissioner will probably never be excelled in the number of inaccuracies, absurd statements, fairy stories and erroneous conclusions it contains.

One other case may be mentioned, one with which the National Academy of Sciences is concerned. In the spring of 1914 the administration decided to send a special commission of zoologists to the seal islands of Alaska. The secretary of commerce, when a member of congress, had voted for a bill which prohibits all commercial killing of fur seals for five years in spite of the fact that every zoologist in America, England, Russia and Japan who had studied our fur-seal herd advised against such a course.

Having taken a position favoring the suspension of commercial killing the secretary might very properly decline to reverse his opinion until he had secured further information. The administration thought this information could be secured by sending a special commission to the islands. To assist in selecting the members of the commission the president asked the National Academy of Sciences, the secretary of the Smithsonian Institution and the secretary of agriculture each to nominate one member of the commission. This was done. The National Academy of Sciences nominated a very able and distinguished zoologist, Dr. George H. Parker, of Harvard University. The commission went to the seal islands in the summer of 1914, made a study of the seal herd and, upon their return to Washington, submitted a very comprehensive report, in which, evidently to the surprise of the secretary of commerce, every important thing for which Clark, Jordan, Evermann, Stejneger, Lucas, Osborn, Townsend, Merriam, Lembkey and others familiar with fur-seal matters had contended, was sustained.

The report contained a number of recommendations, the most important of which was the immediate repeal of the law which prohibits commercial killing of seals, and for which Mr. Redfield had voted and which he had said, as late as October 13, 1913, was "a sound and wise one."

Dr. Parker and his associates submitted their report to the commissioner of fisheries on January 23, 1915, by whom it was promptly transmitted to Secretary Redfield on January 25. Although the report contained recommendations of vital importance to the fur-seal herd, which if acted upon promptly would save hundreds of thousands of dollars to the government as well as save the seal herd from irreparable injury, Mr. Redfield pigeonholed the report for more than three weeks and did not transmit it to congress until February 17, only a few days before congress adjourned. And, very strangely, and to the great disappointment of the commission, Mr. Redfield studiously refrained from calling attention to any of the recommendations of the commission; nor did he make any recommendation himself that congress should take any action

on the recommendations of the commission. In fact, it is understood that it was Mr. Redfield's desire that congress should not take any action. He wholly ignored, and wished congress to ignore, the recommendations of the commission named by the National Academy of Sciences, the secretary of the Smithsonian Institution and the secretary of agriculture. It would be proper for the National Academy of Sciences, the official adviser of the government on scientific matters, to ask the president what action, if any, has been taken on the recommendations of the board which it assisted in naming; and if called upon again for expert advice, the academy would do well to inquire whether any attention would be paid to its advice when given.

The statement in *The Scientific Monthly* article that E. Lester Jones "has proved to be an efficient executive" was probably made without intimate knowledge of the facts. It is well known in the bureau of fisheries that just the reverse was true, as was clearly shown by the very extravagant and unbusiness-like administration of Alaska fishery matters of which Mr. Jones took entire charge. Two or three illustrations may be given. It is understood that the sending of supplies to the seal islands under Mr. Jones's management cost the government several thousand dollars more than it had cost before, and yet the natives suffered severely for want of food.

A certain important scientific investigation of the Alaska salmon, begun in 1910 and which required at least six years to reach conclusive results, was stopped in 1914, thus breaking the continuity of the investigation, with the result that the whole thing must be done over again if the results are to be of any value.

If these illustrations of inefficiency are not enough, inquiry might be made regarding the boat *Roosevelt* purchased by Mr. Jones for the Alaska service.

But if the appointment of a politician to the head of a scientific bureau is justified because the appointee proves to be a good executive, then President McKinley's appointment of Mr. Bowers as Commissioner of Fisheries is fully justified, as Mr. Bowers proved to be an excellent executive, who gave the bureau of fisheries a thoroughly business-like administration, during which more real productive scientific work was done than ever before by the bureau.

BARTON WARREN EVERMANN

FIREFLIES FLASHING IN UNISON

IN SCIENCE of February 4, 1916, page 169, I recorded for the first time an observation made fifty years ago of a large number of fireflies flashing in perfect unison. I have been on the lookout ever since that time for a confirmation of my observations, consulting every book on entomology and watching the fireflies ever since for the recurrence of this phenomenon without success. In *Nature* for December 9, 1915, is recorded a paper by W. G. Blair, Esq., entitled "Luminous Insects" in which reference is made to the remarkable synchronism of the flashes in certain species of European fireflies. A somewhat extended extract is given from Mr. Blair's address. A copy of this paper was sent to my friend Professor E. B. Poulton, of Oxford, and in return he has sent me a proof sheet from a book he is editing entitled "A Naturalist in Borneo" by R. Shelford, who died a few years ago, a former assistant of Professor Poulton. I am taking the liberty of presenting an extract from this advanced page:

> On the opposite bank was a small tree growing close to the water's edge, which was covered with thousands of fire-flies, small beetles of the family Lampyridæ; and I observed that the light emitted by these little creatures pulsated in a regular synchronous rhythm, so that at one moment the tree would be one blaze of light, whilst at another the light would be dim and uncertain. This concerted action of thousands of insects is very remarkable and not easy of explanation. Another instance of it was mentioned by Cox; certain ants that are found very frequently proceeding in columns along the floor of the jungle, when alarmed, knock their heads against the leaves or dead sticks which they happen to be traversing; every member of a community makes the necessary movement at the same time, and as the movements are rapid a distinct loud rattling sound is heard. In this case the action is probably a danger-signal, and we can understand—theoretically at any rate—how it was brought

about. But the value to the species of the rhythmic-light pulsation of the fire-flies is not obvious, and as it is doubtful if the emission of phosphorescent light is under the control of the insect, or is merely a simple automatic process of metabolism, its synchronism is a most puzzling fact.

Dr. Hermon C. Bumpus wrote me that some years ago in riding from Falmouth to Woods Hole his attention was arrested by noticing in a field along the road a large number of fire-flies flashing synchronously.

Edward S. Morse

A FURTHER NOTE ON POLYRADIATE CESTODES

The issue of Science for February 4, 1916, N. S., Vol. 43, No. 1101, page 170, contains a note by Professor Barker referring to my article on "Polyradiate Cestodes" published in the *Journal of Parasitology*, September, 1915, calling attention to the omission of his previously reported cases of triradiate specimens of *Tænia pisiformis* and *T. serialis*, and to my error in considering that the case of triradiate *T. pisiformis* which I reported was the first on record. This is a valid criticism and it is regrettable that Professor Barker's paper should have been overlooked. None of the other criticisms made by Professor Barker, however, seems justifiable.

In the first place, in regard to the specific identification of the parasite, it has been my experience in the course of several years, during which time a large number of specimens of dog tapeworms have been examined, that *Tænia pisiformis* may be readily determined upon the basis of the gravid segments alone.

As to the other criticisms made by Professor Barker, although I attach much less importance to the results of the feeding experiments which I carried out than Professor Barker apparently supposes (for the reason that the results of a single experiment of that kind are of no great value as a rule, except when supplemented by the results of other experiments) it seems proper to discuss briefly certain points in my paper which appear to have been misinterpreted by Professor Barker.

With reference to using, in feeding experiments, material which had been in formalin for a few days, it was noted in my article that the use of such material on several other occasions had always resulted in the infestation of the experiment animals. In fact it has been found by repeated experience by myself and others in this laboratory, that the ova of *T. pisiformis* are extremely resistant to the action of formalin. Rabbits fed segments of *T. pisiformis* which have been kept a few days in a solution of formalin, not infrequently die shortly afterwards and on postmortem examination show a massive invasion of the liver with the early larval stage of the parasite.

It is a well-known fact that in the case of several species of parasites, the ova of which are characterized by a relatively thick egg shell, the eggs are affected but little if at all by formalin solutions. Ascarid eggs for example may be kept alive for months or even years, in formalin. Morris[1] when examining some human feces which contained many eggs of *Ascaris lumbricoides* and which had been preserved in a 2 per cent. solution of formalin for two years, found that some of the eggs contained actively motile embryos. Four months later there was an apparent increase in the number of eggs containing embryos. In my own experience it has been found that a formalin solution is a very satisfactory medium in which to incubate ascarid eggs, as it prevents the growth of molds, bacteria, etc., without interfering with the development of the embryos. Various other substances commonly destructive to protoplasm have been found not to interfere with the development of ascarid eggs. Leuckart[2] notes that the eggs of *Ascaris mystax* may reach complete development in alcohol, chromic acid and turpentine, while Bataillon[3] has had ova of *Ascaris megalocephala* showing living embryos after having been for six months in Flemming's solution. The latter also finds that the embryos in the eggs remain intact and active in 50 per cent. alco-

[1] *Johns Hopkins Hospital Bulletin*, Vol. 22, August, 1911, pp. 299–300.

[2] "Die menschlichen Parasiten," Vol. 2, 1 Lief., 1867, p. 212.

[3] *Arch. Entwickelungsmech.*, Vol. 2, 1901, p. 149.

hol, in a 33⅓ per cent. solution of acetic acid and in a 20 per cent. sulphuric acid solution.

Concerning Professor Barker's suggestion in regard to the uncertainty as to the previous natural infection of the rabbit used, it should be noted that in the article in the *Journal of Parasitology* I stated that it could not be positively demonstrated that the rabbit was uninfested at the time it was fed. Attention, however, was called to the fact that spontaneous infestation among rabbits from the same source was unknown, and it was considered that this was very strong evidence for assuming that the cysticerci found in the rabbit resulted from the feeding experiment. How strong this presumptive evidence was will be seen from the following:

The records of the Bureau of Animal Industry Experiment station at Bethesda, Md., show that about 5,000 rabbits have been reared and used for laboratory purposes. By inquiry among the members of the bureau laboratories where these rabbits have been used, it was learned that cysticerci have never been observed in any case except as the result of experiments in which tapeworm eggs were fed to the animals. As all these rabbits are reared under practically identical conditions and the greater number of them during and subsequent to the experiments in which they are used, are kept until death under essentially the same conditions as my experiment rabbit, it would seem that the feeding experiment with proglottids of a triradiate *T. pisiformis* was very well safeguarded by checks, and that the results though (as was noted) not conclusive, justified the statements which I made to the effect that the feeding experiment in question tended to show that normal larvæ may result from the eggs of triradiate adults, and on the other hand that it failed to demonstrate the development of abnormal larvæ from polyradiate adults. In other words, recognizing the inadequacy of a single feeding experiment, I did not draw any definite conclusions from the results. I accepted these results merely as indicating certain probabilities and placed them on record so that they would be available for reference to others who might have opportunity to undertake feeding experiments with the eggs of polyradiate cestodes.

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QUOTATIONS

SCIENCE AND COMMERCE

IN commenting on the report of the National Physical Laboratory for 1915–16, *Nature* recalls the serious anxiety caused to those responsible for the supply of optical munitions by the shortage of suitable glass at the beginning of the war, for the industry of optical glass production had tended more and more to become a German monopoly. With the aid of a grant from the Privy Council Committee for Scientific and Industrial Research, a number of inquiries were instituted. So far the main work has been directed to the production of satisfactory pots, since one of the principal difficulties in the manufacture of optical glass lies in the choice of suitable material for the pots in which it is made. Similar work on heat-resisting materials, and generally on the behavior of the rare earths and other substances at high temperatures, is of great importance in a large number of industrial processes, but for such work a technological laboratory on a large scale is needed, and will, it is hoped, be provided. Other research on chemical and other glasses has been done during the year by the National Laboratory, as well as by other institutions. The work is of the utmost national and scientific importance, and our scientific contemporary expresses the hope that the committee will spare no effort "to ensure that it is actively continued and extended, and that in the future no risk shall be run of this fundamentally important industry passing into foreign hands."

The committee is in a good position to achieve the first object, and the acquisition of scientific knowledge and the perfecting of technical methods will make the attainment of the second possible, but it will not do more; commercial organization is necessary, and also probably state action. As an example of what

happens we may say that we had occasion a short time ago to make some inquiries as to a particular kind of glass, and found that though its formula was due to British research, and though it had been and perhaps is still being made in this country, commercial control was in the hands of foreigners.

The position with regard to the production of fine chemicals and synthetic drugs and the commerce in them is very similar to that in which the authorities of the National Physical Laboratory found the manufacture of optical glass. In commenting, in the *Journal* of August 12, on the resolutions adopted by the Annual Representative Meeting recommending medical practitioners to avoid using drugs made in Germany or Austria if identical substances manufactured by ourselves or by our Allies can be obtained, and instructing the council to bring to the notice of the government the possibility of guaranteeing protection to firms willing to lay down plants to manufacture drugs and chemicals made in Germany before the war, we pointed out that while it was probably the opinion of the majority of chemical manufacturers that some form of government assistance by tariff or otherwise was necessary, yet a considerable degree of cooperation among manufacturers is a more fundamental requisite for the establishment of the manufacture of synthetic drugs on a sound commercial basis.

It is probably owing to the resolutions of the Annual Representative Meeting and this comment on them that Dr. Sidney Barwise, medical officer for Derbyshire, has sent us a copy of a pamphlet on economics and the war which he published last May. Dr. Barwise refers to the resolution adopted by the Chambers of Commerce of the United Kingdom "that the strength and the safety of the empire lie in ability to produce what it requires from its own soil and factories," and compares it with a famous pronouncement of Alexander Hamilton during the American War of Independence: "Every nation . . . ought to endeavor to possess within itself all the essentials of national supply. These comprise the means of subsistence, habitation, clothing and defence. . . . The possession of these is necessary to the progress of the body politic; to the safety as well as to the welfare of the society. . . . To effect this change, as fast as shall be prudent, merits all the attention and the zeal of our public councils; it is the next great work to be accomplished."

Far be it from us to enter upon the thorny controversy as to free trade and tariff reform, which excites a degree of bitterness in the extreme champions on either side difficult for persons of scientific training to understand, but we are entitled to call attention to the effect on the nation's health and virility of the exodus from country to town, due in part at least to the depression of agriculture and the fact that peasant proprietors in Great Britain are so few as to be negligible in any general view. One result of the fiscal policy of Germany has been to keep the people on the land and to encourage small freeholders; in thirteen years one and a half million acres were thrown into small holdings. A similar fiscal policy in France has had a similar result. Before the passing of the Méline tariff law of 1892 France imported 441 million francs' worth of agricultural produce; ten years later she was exporting an excess of 152 million francs' worth, peasant proprietors had increased and the tide of population was set back from the town to the land. In thirty years the import of cereals into Great Britain more than doubled, while the population increased by less than a third. In the same issue of *Nature* as that from which we have already quoted there is a note on a recent report by Mr. T. H. Middleton, assistant secretary of the Board of Agriculture. He shows that it is not an empty boast to say that on each hundred acres of cultivated land Germany feeds seventy people, while Britain can only feed forty-five. According to this report, the two chief factors in the recent remarkable development of German agriculture are a settled economic policy and a well-thought-out system of agricultural education; coupled with these is the belief of the German farmer that he was essential to the community and that his land should not be allowed to go

out of cultivation. Mr. Middleton states that the chief immediate cause of the increased productivity of German soil is the increase in use of artificial manures; twice as much nitrogen, one third more phosphate, and five times as much potash are used in Germany as on an equal area of our cultivated land. The reason Mr. Middleton gives for this failure of the British farmer is want of education, but he thinks that this defect in our educational system is being remedied. There are, however, undoubtedly other causes, which might more quickly be removed, for the depression which has affected British agriculture during the last seventy and especially the last thirty or forty years.—*British Medical Journal.*

SCIENTIFIC BOOKS

An Introduction to the Study of Color Vision. By J. HERBERT PARSONS, D.Sc., F.R.C.S., Ophthalmic Surgeon, University College Hospital; Surgeon, Royal London Ophthalmic Hospital. Cambridge, University Press. 1915. 308 pp.

Dr. Parsons has undertaken to present the facts and the theories of color vision in such form as shall be intelligible to the general reader. He states in his preface:

> The vast literature on color vision consists almost entirely of papers written in support of some particular theory. It is peculiarly difficult to obtain a general and unbiased view of the subject. I have here endeavored to separate the best established facts of color vision from the theories, and have then discussed the chief theories in the light of these facts.

Accordingly he has divided his book into three parts. The first part (pp. 1–157) is devoted to a statement of the facts of normal color vision; the second part (pp. 158–192) deals with the facts of color-blindness; and the remaining portion (pp. 193–299) discusses theories of color vision.

The author's statement of the facts of normal color vision is prefaced by a brief summary of such phenomena of physical optics and such a description of the structure and function of the visual organ as shall serve as a basis for his subsequent discussion. This is followed by a description of the color vision of the light-adapted eye and of the dark-adapted eye, together with a summary of the temporal and spatial effects of retinal stimulation (after-images, contrast, color-zones and the like). His chapter on the evolution of the color-sense presents evidence derived from the color vision of the lower animals, from the color vision of primitive peoples, and from the color vision of infants. The description of color-blindness summarizes the findings obtained in various investigations of certain typical deviations from normal color vision. The chapters on theories of color vision are prefaced by an historical sketch of the development of color theories, and this is followed by a summary statement of the most widely accepted theories.

Dr. Parsons has attempted a difficult task in his endeavor to present a readable summary of the exceedingly voluminous and exceedingly controversial literature of color vision; and his book bears evidence of painstaking effort and keen insight. The author has exercised sound judgment in selecting and presenting his material; and for the most part he has maintained an admirably non-partisan attitude throughout—except, perhaps, in dealing with the duplicity theory where his approval is more complete than the facts seem to the reviewer to warrant. The features in Dr. Parsons's book which are most likely to excite criticism are the author's tendency toward an uncritical statement of the findings of the various investigators, and his failure to recapitulate his mass of summaries and to give the reader a brief statement of the present status of the various problems. There is perhaps no field of investigation in which the refinement of apparatus and of technique has made greater progress within the past decade or two than in the field of color vision; it follows, therefore, that many of the earlier investigations now possess no more than historical value. It seems to the reviewer to be doubtful wisdom to lump together the findings of good, bad and indifferent investigations, and to present them to the reader without any attempt at critical evaluation. In several instances the

author has employed a loose form of statement—for instance, he speaks of "physiological sensations" (p. 162), and he employs the term color throughout in an equivocal and confusing fashion, sometimes referring to color-stimulus and sometimes to color-sensation; a few inaccuracies of statement are also to be found, of which perhaps the most serious is the assertion that the extreme peripheral region of the retina is totally color-blind (p. 71; p. 258). Although the book will be of doubtful service to elementary students, it may safely be recommended to more advanced workers as a supplement to the earlier and more critical summaries by Mrs. Ladd-Franklin and others in Baldwin's "Dictionary," and by Rivers in Schäfer's "Text-Book of Physiology."

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SPECIAL ARTICLES

THE MAMMALIAN ERYTHROCYTE—A BICONCAVE DISC[1]

The existence of "bell"- or "cup"-shaped red corpuscles in mammalian blood has been recorded frequently since the early observations of Leeuwenhoek (1719).[2] The serious proposal that the cup, and not the classic biconcave disc, is to be considered normal is, however, a comparatively recent teaching which has been received with considerable skepticism. Since these concavo-convex corpuscles may be found in drawn blood, in fixed tissues, and even in circulating blood, the issue obviously hinges on the determination of which is the normal and which the derived form—one or the other representing a modification.

1. *Examination of Drawn Blood.*—It has been claimed (Weidenreich, '02,[3] et seq.; Lewis '04)[4] that drawn blood examined immediately on a warm slide is favorable for the demonstration of cups. According to this view, the assumption of the familiar disc-shape depends on an almost instantaneous change due to the evaporation and concentration of plasma before the preparation can be made and examined.

That the disc-form is normal has been asserted by Jordan ('15)[5] working with blood, diluted with physiological solutions, in culture slides, and by Löhner ('10)[6] who employed a cabinet of sufficient size to contain a microscope and to permit the free use of his hands, introduced through appropriate openings. Within this apparatus, heated to 38° C. and saturated with moisture, blood was drawn from the finger and examined. Löhner reports that the blood corpuscles were "stets und ausschliesslich" biconcave discs.

In ordinary warm slide- and cover-preparations, made as quickly as possible, I have observed a few cups only, but have never followed the transformation of these into discs as the newer hypothesis suggests. The momentary exposure to air necessitated in making ordinary preparations may be practically eliminated by utilizing the following method. Superimposed cover glasses, separated by a hair, are fused at one point by heat; if an edge be now applied to a needle prick in the finger, and the finger squeezed, the issuing blood is drawn in by capillarity. Such preparations, examined quickly, have never yielded evidence for the general existence of the cup-shape. A few cups may usually be found, whereas scores of indubitable discs appear.

Since the experiments of Ranvier, in 1875,[7] it has been known that graded temperatures can alter disc-shaped corpuscles to shallow cups, thick-walled cups or even to spheres—*e. g.*, typical cups are found exclusively when blood is warmed to 55° C. (Zoth).[8] Is it possible that some investigators, who advocate the

[1] From the Anatomical Laboratory of the Northwestern University Medical School, Contribution No. 43, July 2, 1916.

[2] Leeuwenhoek, A., "Epistolæ physiologicæ," epistola 44, 1719.

[3] Weidenreich, F., *Arch. f. mik. Anat.*, Bd. 61, pp. 459–507, 1902.

[4] Lewis, F. T., *Jour. Med. Research*, Vol. 10 (N. S., 5), pp. 513–517, 1904.

[5] Jordan, H. E., *Proc. Soc. Exp. Biol. and Med.*, Vol. 12, No. 7, pp. 167–169, 1915.

[6] Löhner, L., *Arch. f. gesam. Physiol.*, Bd. 131, pp. 408–424, 1910.

[7] Ranvier, L., "Traité technique d'Histologie," 1st ed., Paris, 1875.

[8] Zoth. Vide Löhner, *op. cit.*

cup shape, have heated unduly their slides and covers in overzealous attempts to maintain normal(!) conditions?

Experimentation in which various "physiological solutions" are used for the dilution of blood may ever, though perhaps unjustly, be subjected to criticism. At best these are artificial media, the tonicity and colloidal constitution of which may or may not simulate blood plasma.

To preclude such criticism natural serum must be used. Accordingly, I had 20 c.c. of blood drawn from my basilic vein. This was defibrinated by whipping and centrifuged quickly; thus an examining medium was obtained, identical with blood plasma except for the loss of one of its minor protein constituents —fibrin.

By utilizing an electrically heated warm-stage, hollow-centered life slides, cover glasses, as well as the air of the cell itself, may be maintained constantly at body temperature. A drop of serum was placed on a finger, previously cleaned with alcohol, and the finger pricked through the drop. The droplet of blood, thus diluted, was touched to a cover and suspended, as a hanging drop in the life cell. Vaseline served to seal the cell, the air in which could be kept saturated with moisture by introducing previously a drop of water and sealing. A few seconds only are required to make such preparations; if a large drop of serum be used the loss by evaporation prior to sealing is inconsiderable, whereas further evaporation in the cell can not occur.

A microscopic examination of blood prepared according to this technique reveals numerous isolated corpuscles. A favorable place for scrutiny is near the center of the drop. Here sinking corpuscles revolve slowly, showing alternately their concave faces. *Usually a few cups can be found, whereas quantities of discs are seen in every field.* This experiment may be varied by filling shallow concave slides with serum into which the drop of diluted blood is introduced. Evaporation is prevented by sealing with a cover and vaseline.

Human sera, kindly furnished by three of my colleagues, gave results identical with those already described, both when corpuscles were examined in their own serum and in each of the other sera. Similar tests have also been made with .85 per cent. and .9 per cent. saline, and with Tyrode's solution. More cogent proof concerning the primary shape of the mammalian erythrocyte, to be derived from the study of drawn blood, I can not imagine.

Various dilutions of human serum with distilled water were next prepared. When a droplet of blood is mixed with a drop of diluted serum containing ca. 40 per cent. water and examined as before, typical cups are found almost exclusively; in dilutions containing ca. 65 per cent. water deeply dimpled spheroids appear; perfect spheres result when the water content is ca. 70 per cent. In concentrated serum erythrocytes crenate. It is evident, therefore, that the shape of a corpuscle is, at least in part, a function of the concentration, *i. e.*, the osmotic pressure, of its medium. In progressively hypotonic solutions corpuscles imbibe increasing amounts of water, ultimately becoming spheres and laking. In hypertonic media, water is given up and crenation results. It is interesting to note that between wide limits these form changes are repeatedly reversible—for example, crenated corpuscles may be restored to the disc- or cup-shape and then recrenated.

The importance of these dilution phenomena on the question of the normal shape of erythrocytes seems to me paramount. *Since the form of a corpuscle depends on the concentration of its medium, how can the cup-shape be normal when human serum must be diluted one third to produce this type?*

Experimentation with the serum of cats and dogs has given comparable results, both with their own and with human corpuscles. The rat, guinea-pig and rabbit have afforded variable pictures, which I believe indicate that the rodent's blood plasma may possess individual variability in its tonicity, thereby rendering this group of animals unfitted for experimentation of this kind.[9]

[9] Details will be given in a later contribution of which present paper constitutes a preliminary note.

2. *Observations on Circulating Blood.*—Weidenreich reported having observed cup-shaped corpuscles in the mesentery of the rabbit ('02) and in the wing of the dormant bat ('03).[10] Lewis ('04) drew similar conclusions from a study of the guinea-pig's omentum, whereas Triolo ('05)[11] recorded finding complete spheres in this animal. Jolly ('05 et seq.),[12] working on the wing of bats restored from hibernation, and Schäfer ('12)[13] on certain mammals (sp. ?) maintain that discs occur. Jordan ('09)[14] found both types, in approximately equal numbers, in the cat.

To avoid the pressure on the vessels caused by the ordinary use of a cover glass and an oil immersion objective, I employed Tyrode's solution (without a cover glass) as in the water-immersion objective of former days. A Leitz no. 4 dry objective and a no. 12 compensating ocular, with the draw tube set at 190 mm. also gave satisfactory magnification.

The omenta of 8 cats and 2 dogs were studied for periods of from 1 to 4 hours. The animals used were in a state of deep surgical shock, the anesthetic having been stopped 2 to 4 hours previously. Regions of the omentum where temporary stasis has caused corpuscles to adhere in clumps or agglutinated masses I do not consider favorable. Ordinary circulation is much too rapid to enable one to make accurate observations. It is sometimes possible, however, to find a bifurcation of medium sized vessels in which the rapid flow selects one limb almost exclusively, separate corpuscles, nevertheless, being intermittently "kicked off" into the slowly moving plasma of the other limb. Such a situation, where the flow is rapid and normal (to find which has sometimes necessitated an hour or more of diligent search) I regard as most favorable for study.[15] Criticisms of pressure from the microscope and of observing capillaries so small that the corpuscles must adjust themselves to their exiguous confines are obviated.

Erythrocytes emerging from the main stream in the way indicated were found to be almost exclusively discs; most of these corpuscles are revolving when first seen and it is easy to be certain of their biconcavity. In such situations I have observed, and have shown to my colleagues, hundreds of discs with only an occasional cup- or saucer-form.

In *anesthetized* guinea-pigs and rabbits cups were very common, and in a dog, under ether anesthesia, a great preponderance of cup-shapes were observed. Is the anesthetic responsible for the cup-shape? The following experiment is highly suggestive. A hanging drop preparation of human blood, or of the blood of a cat or dog, diluted with serum is made. If a drop of ether or chloroform be introduced into the bottom of the cell, the drop takes on the vapor and the discs are seen to change rapidly first to shallow cups, then to deep cups and spheres.

I believe that my observations indicate that the erythrocytes of normal circulating mammalian blood are biconcave discs, the burden of proof resting on those who have used anesthetized animals to show that the anesthetic held in the blood is not responsible for the preponderance of cups observed.

3. *Action of Fixitives.*—Many workers have recorded that mammalian tissues, preserved in various standard fixatives, contain cup-shaped erythrocytes. Should great weight, however, be given evidence of this sort? These corpuscles are plastic structures of extreme delicacy, mere contact with adjacent corpuscles or with obstacles sufficing, when gentle streaming is induced, to cause excessive and varied temporary distortions. Fixation is essentially a coagulation process and it has been shown that the so-called best fixatives actually diminish the diameter of the corpuscle. If, therefore, the reagent does not act on all sides of an erythrocyte simultaneously is not a buckling of the side first fixed to be expected? Indeed

[10] Weidenreich, F., *Ergeb. d. Anat. u. Entwickl.*, Bd. 13, pp. 1–94, 1910.

[11] Triolo, *Gazz. d. ospitali, Milano*, Vol. 26, p. 393, 1905.

[12] Jolly, J., *Comp. rend. soc. biol.*, T. 58, pp. pp. 481–483, 1905.

[13] Schäfer, E. A., "Quain's Anatomy," Vol. 2, Pt. 1; 11th ed., Longmans, Green & Co., London, 8vo, 11 and 739 pp., 1912.

[14] Jordan, H. E., *Anat. Anz.*, Bd. 34, No. 16 u. 17, pp. 406–412, 1909.

[15] For making these observations I can particularly recommend the dog's omentum.

a biconcave shape would invite this alteration. It seems plausible that the delicately constructed and highly flexible erythrocyte is more easily subject to distortion, through the action of reagents, than are ordinary tissues for it is not supported by contiguous cells or by intercellular cement.

The following experiment of Löhner ('11),[16] which I have corroborated, is interesting from this viewpoint. If a droplet of blood be drawn by capillarity between cover slips,[17] fused at one point, discs are observed. If now 1 per cent. osmic acid be drawn in cautiously from one side only, many cups, some wedge-shaped discs, discs, and distorted forms are seen.

A limited number of cup-shaped erythrocytes undoubtedly exist in normal blood. Possibly they represent corpuscles, whose structure is such that unequal tensions with respect to the osmotic balance exist; perhaps they are old (or young?) corpuscles. In anemias the presence of many cups have been reported, and in fevers it is said crenation may occur. May it not be that the blood of certain individuals contains "normally" excessive numbers of cup-shaped corpuscles? Is it possible that this explains why some of our most careful workers have been led to describe this form as normal?

The evidence gained from the examination of drawn blood, diluted in human serum, and from the study of circulating blood in non-anesthetized living mammals justifies, I believe, the conclusion that the biconcave disc represents the normal shape of the mammalian erythrocyte—the concavo-convex cup being merely an occasional modification.

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THE PENETRATION OF BALANCED SOLUTIONS AND THE THEORY OF ANTAGONISM

ANTAGONISM has been explained by Loeb and by the writer on the ground that antagonistic substances prevent each other from entering the cell. As the writer has repeatedly pointed out,[1] this explanation encounters a difficulty in the fact that antagonistic substances penetrate the cell in a balanced solution (although the penetration is much slower than in unbalanced solutions). The proof of this has been obtained by the writer by means of the method of plasmolysis[2] as well as by determining electrical resistances[3] and it has recently been confirmed by Brooks[4] by means of the method of tissue tension as well as of diffusion through a disk of living tissue.

It is obvious that antagonistic substances must penetrate in a balanced solution since otherwise the cell could not obtain the salts necessary to its existence.

As a way out of this difficulty the writer has suggested[5] that the slow penetration of salts may produce effects quite different from those produced by rapid penetration, just as the precipitation of colloids may be brought about by the rapid addition of salts while it does not take place when they are added slowly.

This difficulty completely disappears if we adopt the standpoint recently advocated by the writer in developing a dynamical theory of antagonism.[6] From this point of view we regard the slow penetration of salts in balanced solutions not as the cause but as the result of antagonism, or rather we may regard both the slow penetration and the increased length of life (or growth, etc.), by which we measure antagonism, as the results of certain life processes which are directly acted on by the antagonistic substances.

The essential feature of the explanation lies in the behavior of these life processes rather than in the manner or rate of penetration.

It is assumed that these life processes consist of consecutive reactions of the type

$$A \rightarrow M \rightarrow B$$

[16] Löhner, L., *Arch. f. gesam. Physiol.*, Bd. 140, pp. 92–108, 1911.

[17] Blood should occupy part of the capillary space only.

[1] SCIENCE, N. S., 34, 189, 1911; 35, 115, 1912; 36, 576, 1912. *Plant World*, 16, 135, 1913.

[2] SCIENCE, N. S., 34, 189, 1911.

[3] SCIENCE, 35, 115, 1912; 36, 576, 1912. *Am. Jour. of Botany*, 2, 93, 1915.

[4] Unpublished results.

[5] SCIENCE, N. S., 34, 189, 1911; 35, 115, 1912; 36, 576, 1912. *Plant World*, 16, 135, 1913.

[6] *Proc. Am. Phil. Soc.*, 55, 1916.

in which M is a substance which determines the rate of penetration of salts and the electrical resistance of the protoplasm.

If the antagonistic substances are NaCl and $CaCl_2$ it appears that $CaCl_2$ accelerates the reaction $A \rightarrow M$ while both $A \rightarrow M$ and $M \rightarrow B$ are inhibited by a salt compound formed by the union of NaCl and $CaCl_2$ with a constituent of the protoplasm.

From this standpoint the slow penetration of antagonistic substances should not have unfavorable results provided these substances are properly balanced at the start and remain so (*i. e.*, if their relative proportions are not too much changed by unequal speed of diffusion, precipitation, chemical union, etc.) after they enter the cell. For they must affect the life processes mentioned above in quite the same way in the interior of the cell as at the surface[7] and these life processes will go on in the normal way so long as the antagonistic substances within the cell remain properly balanced.

The result will be the preservation of normal permeability as well as of all other properties essential to life.

It has been shown by the writer[8] that the normal permeability may be regarded as a sensitive and accurate indicator of health and vitality. All factors which disturb it bring about temporary or permanent injury and eventually produce death if the action be sufficiently prolonged. It is therefore evident that the life processes which preserve normal permeability are of peculiar importance and that the manner in which they are influenced by antagonistic substances is of especial interest. Methods are being developed for the study of these questions and it appears probable that a considerable amount of information can be obtained in regard to the nature of these processes.

Summary.—Antagonism has been explained by assuming that antagonistic substances prevent each other from entering the cell. A difficulty is found in the fact that they slowly penetrate the cell even in a properly balanced solution. This difficulty disappears if we suppose that the antagonistic substances affect certain life processes which control permeability. So long as they are present in the right proportions their effect on these processes is favorable and their penetration into the cell can do no harm.

The preservation of normal permeability may therefore be regarded as the result rather than as the cause of antagonism.

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[7] Whatever effects are found at the outer surface of the cell are doubtless to be found also at many of the internal surfaces such as the surfaces of vacuoles, plastids, microsomes, etc.

[8] *Plant World*, 16, 143, 1913. Science, N. S., 40, 488, 1914.

THE DETERMINATION OF RELATIVE HUMIDITY

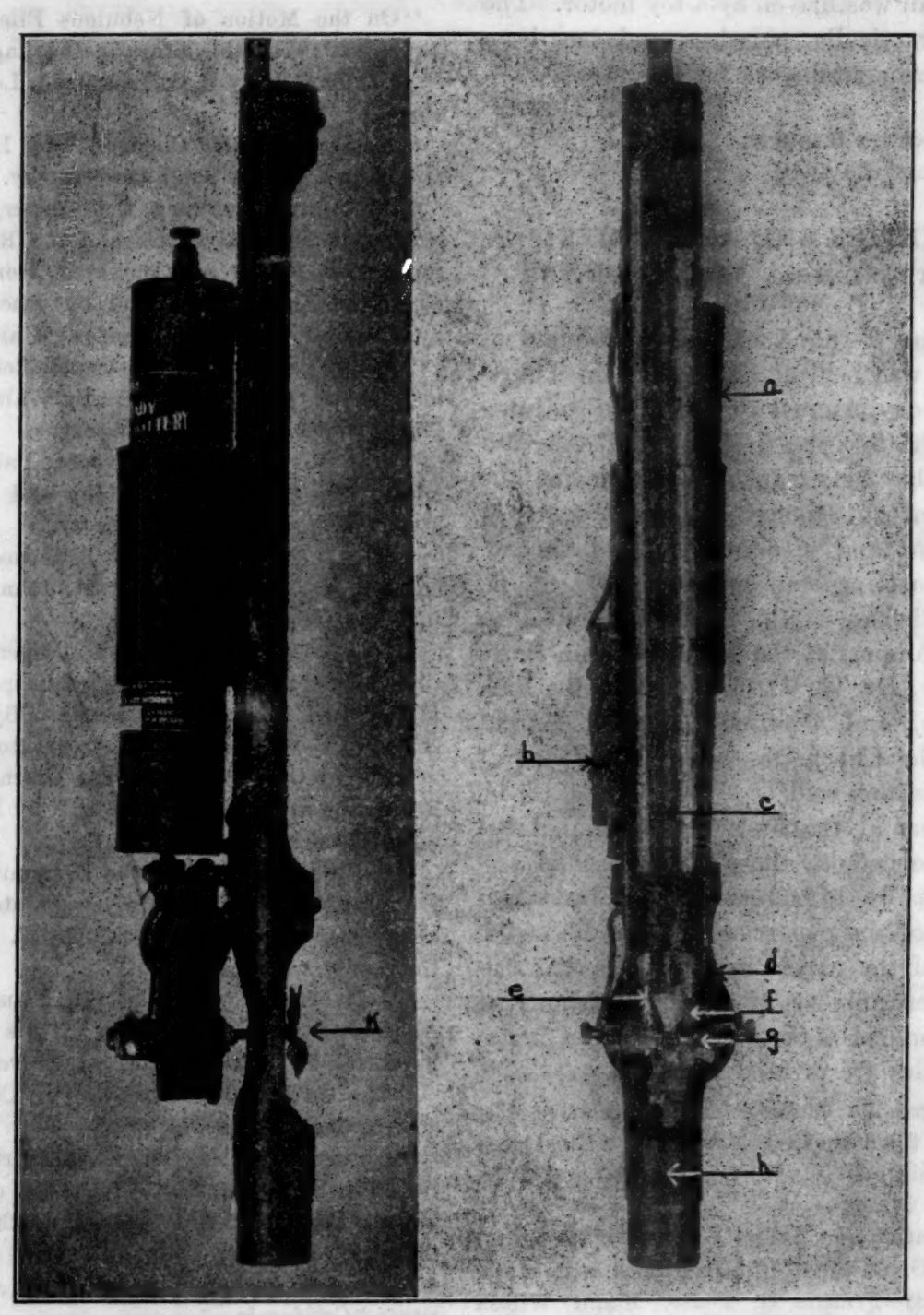
In the present stage of knowledge of what constitutes healthful and comfortable air for the average healthy person, the question of the value and significance of the determination of relative humidity is still decidedly debatable. It will, therefore, be necessary to continue such determinations in connection with other types of ventilation tests, in order to assign to relative humidity its proper value as a factor in the problem of conditioning air for health and comfort. There is at least one standard procedure for this determination—the use of the sling psychrometer. This instrument is supposed to give reliable results if used in accordance with the government directions. One need not spend the fancy price for the instrument de luxe. Two thermometers, firmly lashed together in such a way that the bulb of one projects beyond that of the other gives perfect satisfaction. The lower bulb is moistened in the usual way and the pair is swung by a strong cord.

This method has obvious limitations. It can not be used under many circumstances where the determination of relative humidity is desired, *e. g.*, in crowded places, between skin and clothing, etc. It is ofttimes inconvenient and dangerous to use, *e. g.*, in conspicuous places such as churches and libraries, and in cramped quarters such as the berths of

sleeping cars. Outside the realm of hygiene, it is often unsuitable, for example for determining relative humidity among the stems and leaves of seedling plants.

by the obvious and simple method of using a motor-driven fan, but also a graphic record of the readings is kept.

If a continuous record is not desired, it is



a. Dry cell. *b*. Key. *c*. Tube leading to water reservoir. *d*. Motor. *e*. Dry-bulb thermometer. *f*. Wet-bulb thermometer. *g*. Fan. *h*. Water reservoir. *k*. Direction of air current.

To obviate these difficulties, there have been put upon the market within the last two or three years mechanisms in which not only is the ventilation of the wet bulb accomplished

obvious that the fan ventilation of the thermometer bulbs presents no mechanical difficulties and offers some advantages over the sling method.

In August, 1913,[1] I described such a device in which the fan was moved by clock-work. This I used with satisfaction for a year, but replaced it (see figs.) by an apparatus in which the fan was driven by a toy motor. The latter is practically noiseless and has been used in experimental work for two years.

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SOCIETIES AND ACADEMIES

THE ASTRONOMICAL SOCIETY OF THE PACIFIC

A meeting of the Astronomical Society of the Pacific was held at San Diego on Thursday and Friday, August 10 and 11, in conjunction with the first meeting of the Pacific Division of the American Association for the Advancement of Science. In the absence of the president and vice-presidents of the society, the meeting was opened by Dr. R. G. Aitken, chairman of the program committee. Dr. W. S. Adams, of the Mount Wilson Solar Observatory; Dr. W. W. Campbell, of the Lick Observatory, and Professor Charles Burckhalter, of the Cabot Observatory, presided at the three sessions held.

The papers at the first session related entirely to the nebulæ, those at the second session principally to spectrographic investigations. All of the papers were fully discussed. Abstracts of the papers are given in the August–October number of the Publications of the Astronomical Society of the Pacific, hence only the titles are printed here.

"Spectrographic Observations of Relative Motions within the Planetary Nebulæ." (Illustrated with stereopticon.) By W. W. Campbell and J. H. Moore, Lick Observatory.

"The Rotation and Radial Velocity of the Spiral Nebula, N. G. C. 4594." (Illustrated with stereopticon.) By Francis G. Pease, Mount Wilson Solar Observatory.

"Forms of Planetary Nebulæ." (Illustrated with stereopticon.) By H. D. Curtis, Lick Observatory.

"Color-photographs of Nebulæ." (Illustrated with stereopticon.) "A Simple Method for Determining the Color of a Star," by Frederick H. Seares, Mount Wilson Solar Observatory.

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[1] *Amer. Jour. of Pub. Health*, III., 8, August, 1913.